PROTECTIVE ACTION DECISION-MAKING DURING THE 2019 DALLAS TORNADO

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The 2019 Dallas Tornado struck a densely populated area, was the costliest tornado in Texas history, and had minimal warning lead time, yet there were no serious injuries or fatalities. To understand why, this study examines individuals' decision-making processes during this tornado using the protective action decision model (PADM). Specifically, it investigates the factors affecting threat belief and evaluation, the facilitators and impediments to protective action, and the effects on future risk perception and hazard adjustment measures. Semi-structured telephone interviews were conducted with 23 survivors to explore their experiences and decision-making processes during this tornado. Interviews were analyzed through inductive coding and a constant comparative approach. Key findings of this study suggest that clear and direct warning messages, coupled with rapid, heuristic-driven reactions, can overcome the impediment of a short-fuse warning time and motivate those at risk to take protective action. Additionally, this study identifies condominium owners as a housing population with unique needs and impediments in the tornado recovery process. Furthermore, results illustrate how the hazard scenario and contemporary technological culture nuance protective action decision-making and future hazard adjustment measures.

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LIST OF ABBREVIATIONS

EF	Enhanced-Fujita Tornado Scale
ENT	Emergency norm theory
HOA	Home-owners association
IBW	Impact-based warning
NWS	National Weather Service
NOAA	National Oceanic and Atmospheric Administration
OEM	Office of Emergency Management
PADM	Protective action decision model
PAR	Protective action response
SBW	Storm-based warning
SoVI	Social Vulnerability Index

CHAPTER 1

INTRODUCTION

On the evening of October 20, 2019, a series of severe thunderstorms developed and moved across north-central Texas, producing several tornadoes. Over the next few days, the National Weather Service (NWS) office in Fort Worth, Texas, confirmed a total of 10 tornadoes. The most destructive tornado in this outbreak was an EF-3 that carved a nearly 16-mile path across the Preston Hollow neighborhood in the northern area of Dallas, Texas. Amazingly, no one was significantly injured or killed. The estimated cost of insured damage for this tornado was $1.5 billion, with the entire outbreak totaling over $2 billion. The Insurance Council of Texas asserts this was the costliest tornado event in state history (National Center for Environmental Information [NCEI], 2020). Continued development in tornado-prone regions increases exposure and vulnerability of individuals to their impacts, thus increasing the likelihood for disruptive and destructive events (Ashley & Strader, 2016; Siebeneck, 2016; Strader et al., 2017). Based on the unprecedented economic toll of the 2019 Dallas Tornado and the population density where it struck, a lack of serious injury or fatality is extraordinary. Therefore, this study examines social and environmental cues that informed survivors' threat beliefs and evaluation, survivors' response activities, and how this experience may affect survivors' future protective action decision-making. The following research questions guide the study:

RQ1: What environmental and social factors affected individuals':

(a) threat beliefs?

(b) threat evaluation processes?

RQ2: What aspects facilitated or impeded:

(a) the protective action decision-making process?

(b) ultimate actions undertaken by individuals?

RQ3: How has this tornado experience affected individual's anticipated protective action decision-making process for future tornadoes?

Much of the retrospective or event-based research has used quantitative surveys to examine how warnings and environmental factors affect protective action (Lindell et al., 2019; Stokoe, 2016; Weyrich et al., 2018). This study, by contrast, examines protective action decision-making through a qualitative approach using semi-structured interviews and a constant-comparative analysis. Phillips (1997, p. 185) notes that a "disaster challenges communities in unexpected ways, and with unanticipated consequences, [and] qualitative disaster research can capture human behavior at its most open, realistic moments." This methodology was selected because it provides flexibility during data collection and analysis for survivors to thoughtfully consider their tornado experience and provide a more detail-rich description (Donner & Diaz, 2018). Considering much of the recent research on how people respond to tornado warnings is quantitative in design, this study adds to the current body of knowledge by qualitatively analyzing survivor narratives to better understand decision-making processes during the 2019 Dallas Tornado.

The findings of this study suggest that in a tornado with a minimal warning lead-time, messages that use clear and direct language are effective at motivating those at risk to take protective action. The success of these messages is because they provide enough information for a rapid (knee-jerk) protective action response, after which individuals are able to use modern technology to seek out confirmatory information on the tornado threat from a place of safety. This is particularly beneficial during nocturnal tornadoes, where a lack of environmental cues often diminishes an individual's confirmation capacity. Another key finding is how individuals who own their home but do not have complete control of their property face a unique set of

challenges during recovery (similar to a divided-tenure situation). In this study, condominium owners had less input during reconstruction that prevented them from adopting certain hazard adjustment measures compared to those who have sole ownership of their house (inside and outside) as well as their property.

The following section presents previous literature on risk perception, including applications of the protective action decision model (PADM), which serves as the theoretical framework for this study. Next, the methodological approach used in this study is presented, including how data was collected and analyzed. This is followed by a thematic analysis of the results for this study, presenting the factors affecting participants' threat belief and evaluation processes, the situational impediments and facilitators to protective action decision-making and implementation, and how this disaster effects risk perception and future tornado adjustment measures. The final section discusses how the findings of this study relate to PADM and past research and inform disaster researchers and practitioners in world of rapidly changing technologies and increasingly frequent and severe hazard events.

CHAPTER 2

LITERATURE REVIEW

The protective action decision model (PADM) stems from the theories on risk and risk perception developed in psychology. Therefore, this literature review begins by exploring the concepts of risk and risk perception, discussing how they inform the PADM. The evolution of the PADM and its influence in disaster research are then considered. Finally, previous research informing attributes of the model, such as the social and environmental context and situational facilitators and impediments, are presented. By examining the concepts of risk and risk perception and explaining each of the attributes found in the PADM, this section informs this study's methodological approach.

Risk Perception

The concept of risk—which is derived largely out of psychology—reflects an "uncertainty about and severity of the consequences (or outcomes) of an activity [or circumstance] with respect to something human's value" (Aven & Renn, 2009, p. 1). This approach views risk as inherently subjective and measurable (Slovic, 1992), with the thing that human's value referring to their tangible possessions (e.g., homes, automobiles, etc.), social structures (e.g., family, community, etc.) and personal well-being. Building on this approach, risk perception refers to both "one's awareness of and assessment about a risk" (Demuth, 2016, p. 8). In the context of disasters, risk perception describes the likelihood of a hazard, where and when it may occur, and its potential impact(s) on people and property (Wu, 2020).

Heuristics and Hazard Adjustment

Individual's delineate and deal with risk across two decision heuristics. First,

their affect heuristic describes risk as positive and negative feelings (Bateman et al., 2007), and “fast, instinctive, and intuitive reactions” to threats or hazards (Slovic et al., 2004, p. 311). This mental process is particularly important with unexpected and rapid-onset threats like tornadoes. Second, one’s availability heuristic incorporates experience into how they perceive a threat or hazard (Tversky & Kahneman, 1982). Experience with a certain hazard is important because it “generally leads people to see hazards as more frequent and to view themselves as potential future victims” (Weinstein, 1989, p. 46). In context of tornadoes, an individual’s availability heuristic may draw from both direct and indirect experiences. A direct experience with a tornado “is acquired through one’s own, unmediated participation in the threat and/or event,” while indirect experience comes through mediated participation by “reading, viewing, or hearing information about conditions or impacts from others” (Demuth, 2016, p. 33). Together these decision heuristics influence people’s adjustment measures to a particular hazard or threat, such as a tornado.

Adjustment measures are the various activities available to cope with, and reduce risks (Burton et al., 1993; Slovic et al., 1974). These actions reflect both hazard mitigation and emergency preparedness, with the former describing the protection of “persons and property at the time of impact” and the latter supporting “active response after the impact has occurred” (Lindell & Whitney, 2000, p. 13). For example, tornado mitigation activities include purchasing insurance or installing wind-resistant windows, while preparedness measures include putting together a kit of emergency supplies to deal with the disruption of services after a tornado strikes.

Drawing from the hazards geography tradition in disaster science—which places the onus of disasters on the built environment and human-hazard relationship—public policies and stakeholder perceptions are key factors that

influence the adoption of these adjustment measures (White, 1994). Policies and the credibility of stakeholders are instrumental in how people approach the complexities involved in adopting adjustment measures, as well as the extent to which warnings are understood and heeded (Palm, 1981). While “there are generic sets of adjustments applicable to all hazards,” adoption of these measures “may be limited for any individual or group.” However, “over time some short-term adjustments become part or fabric of adaptation” throughout a community (White et al., 2001, p. 88). The complexities embedded in the adoption of short- and long-term adjustment measures are all the more reason for continued research and investigation.

Risk Perception and Extreme Weather

Tornado risk perception among individuals has been examined after actual events as well as through hypothetical scenarios. Post-event studies have examined relationships between risk perception and individuals’ predetermined beliefs about their local tornado risk (Klockow et al., 2014) and their environmental context and cues (Schumacher et al., 2010). Experimental studies on tornado risk perception have explored how people interpret social cues, such as media reports (Zhao et al., 2019), type of alert (e.g., watch versus warning) (Gutter et al., 2018), and tornado warning polygons (Lindell et al., 2016). Experimental methods have also been used to study tornado risk perception based on environmental cues. In their study on tornado risk perception, Dewitt et al. (2015) asked people to look at pictures of various clouds and determine if they were tornadic or not. They found that participants’ heuristics were generally effective for recognizing tornadic clouds (70% accuracy); however, these heuristics led to biases in the misclassification of some clouds simply because they were dark.

Research on the impact of experience and risk perception varies, primarily because it can be undertaken using a wide variety of measures (see Demuth 2018 for a synthesis of these measures). Studies on the how hazard experience affects risk perception have applied a number of different methods and, as a whole, suggest the connection between experience and risk perception is complex. Post-event studies have revealed that for some an optimism bias may bolster subjective assessments of well-being but also dissuade preparedness for future tornadoes (Suls et al., 2013). In their study on experience and hurricane evacuations, Rickard et al. (2017) found "positive relationship between experience and risk judgment," but a "complex relationship between attribution of responsibility for an unwanted outcome, experience with a risk, and risk judgment" (p. 2344). Perreault, Houston, and Wilkins (2014) investigated experience with individual characteristics and warning message verbiage and found response intentions were not affected by message verbiage. Keller, Siegrist, and Gutscher (2006) also used experimental methods to examine how one's affect and availability heuristic shapes risk perception to flooding. They found that participants who could recall affect-laden images about floods based on their own experiences displayed higher levels of risk perception compared to those who could not. The role of tornado experience with desired warning lead time is another complex concept in research. When framing experience as either going through a tornado warning and an actual tornado, Hoekstra et al. (2011) found that people with experience preferred lower lead times than those who had not. They suggest one possible explanation for this being higher levels of preparedness (i.e., having a plan or designated shelter) compared to people without experience. A study conducted by Prelog and Miller (2013) found that residents of rural Texas exhibited high risk perception for tornadoes despite many

never having a direct experience. In survey of residents in two counties in Alabama affected by a major tornado outbreak, Wallace, Keys-Mathews, and Hill (2015) found no significant differences in tornado risk perception between those living in the damage path (direct experience) and those who did not (indirect experience). This research highlights how one's availability heuristic not only influences risk perception, but also how policy and stakeholder's level of community engagement affect tornado literacy and perception.

Public policies and stakeholders have the capacity to shape a community's tornado risk perception and safety. For example, Eidson et al. (1990) found that people who were more knowledgeable about tornadoes were more likely to have participated in a tornado drill, and Liu et al. (1996) found that a lack of tornado risk comprehension was linked to a failure to take action when a warning was issued. Additionally, Allan et al. (2017) found that risk literacy (based on tornado knowledge and experience) partially overcomes a belief in tornado myths because it informs individuals on the phenomena itself and provides a functional understanding of official warnings. This emphasizes the vital role of polices and stakeholders with increasing tornado literacy across the communities they serve. However, it is important for individuals to feel a personal responsibility for the adoption of the measures and not relying on stakeholders alone (Mulilis & Duval, 1997).

Research on other environmental hazards (e.g., hurricanes, earthquakes, etc.) also informs the extant knowledge on tornado risk perception. In a study on how experience affects hurricane evacuation behaviors among tourists in Florida, Matyas et al. (2011) found that tourists with hurricane experience were less likely to evacuate compared to those without any experience. They indicate potential reasons for this being that tourist's hurricane experience may reflect lower magnitude events

or difficulties encountered during previous evacuations attempts (i.e., crowded or closed roads or transportation hubs). In a study on experience and earthquake preparedness, Becker et al. (2017, p. 188) found seven different influences from experience: “prompting thinking and talking; raising awareness and knowledge; helping individuals understand the consequences of a disaster; developing beliefs; developing preparedness; influencing emotions and feelings; and prompting community interaction on disaster issues.” The research on environmental hazards illustrates the complexities in how individuals perceive risk based on decision heuristics, which are shaped by their own feelings and experiences as well as public policies and stakeholder credibility. These studies also underscore the critical importance of continuing to examine risk perception and environmental hazards such as tornadoes.

Severe Weather Warnings

Warning messages reflect a process, both in the creation of their content as well as how they are received and responded to by the public. In their guidance report on the best practices for warning the public of an imminent threat, Kuligowski and Kimball (2018, p. 12) suggest that an effective warning message includes five types of information about a hazard (see also Mileti and Peek, 2000; Mileti and Sorensen, 1990; Sutton et al., 2014): type and severity, location, timing, protective action recommendation (PAR), and source of the message. In addition it is imperative for warnings to retain consistency across the different information channels available to those at risk (Drabek, 1986; Lindell, 2018; Mileti et al., 1975). After a warning message is disseminated, the decision-making process for those at risk begins. Mileti (1999, p. 141) describes this decision-making process for people across seven stages: (1) hearing the warning; (2) trusting the warning; (3) confirming

the warning; (4) personalizing the information; (5) determining an appropriate protective action; (6) determining if protection is feasible; and (7) determining what action to take and ultimately taking it. Additional factors to consider with severe weather warnings are the false alarm and cry-wolf effects, with the former describing the issuance of a warning without the occurrence of the threat (Sherman-Morris et al., 2018) and the latter referring to an overabundance of warnings issued during a single event (Barnes et al., 2007). The influence of false alarms the cry-wolf effect on response behavior is inconclusive, and varies between different hazards (Brotzge & Donner, 2013). Nevertheless, the principles of an effective warning message are applicable to severe weather events and essential for stakeholders with communicating urgent information to the public about the specific threat and how to respond.

Tornado warning messages are often issued just minutes before the hazard's onset, leaving people in harm's way little time to make protective action decisions (Carbin et al., 2013; Lindell, 2018). Lindell, Sutter, and Trainor (2013, p. 379) note this is particularly dangerous as "warnings with lead times up to about 15 minutes significantly reduce fatalities by up to 50% relative to a comparable tornado with no warning." However, too much lead time can negatively influence the public's confidence in the message (Lazo et al., 2009) and diminish protective action (Hoekstra et al., 2011).

Nocturnal tornadoes further complicate the warning process and protective action responses. Nighttime tornadoes, like the Dallas tornado, often lack visual environmental cues, and consequentially, they tend to be more deadly and less likely to be warned (Ashley et al., 2008; Brotzge & Erickson, 2010; Childs & Schumacher, 2018; Simmons & Sutter, 2005, 2008). Due to the absence of visual confirmation of a

tornado, the format of warnings, their channels, and how they are interpreted are all the more important to study.

Warning Formats

Individuals can receive tornado warning messages from both formal and informal sources. Formal warning messages are those disseminated by governmental or organizational stakeholders tasked with monitoring conditions and providing real-time information about the potential for tornadogenesis and communicating when a tornado threat becomes imminent. Since 2007, storm-based warnings (SBW) issued by the NWS use a polygon to illustrate the specific area in danger; however prior to 2007, tornado warning graphics were issued at the county level (NWS, 2007). Research shows individuals a higher likelihood of personal impact and consequence from a tornado when they are more centrally located within a SBW (Ash et al., 2014; Lindell et al., 2016; Miran et al., 2020; Schumann et al., 2018; Simmons & Sutter, 2011).

In response to the tornado losses of 2011, the NWS changed the language used in tornado warning messages to emphasize the possible impacts associated with these events. These impact-based warnings (IBW) provide direct information on the potential consequences to stakeholders and the public to encourage protective action (National Oceanic and Atmospheric Administration [NOAA], n.d.). Although the fear appeals perspective (Witte et al., 2001) indicates that higher risk perception is a motivator for protective action, recent studies disagree on the effectiveness of IBWs (Casteel, 2018; Harrison and Karstens, 2017; Morss et al., 2018; Perreault, J. Brian Houston, and Wilkins, 2014; Potter et al., 2018) and justify further inquiry. Above all, the SBW/IBW methods provide greater precision and quality of information to those in danger in order to spur protective action.

Warning Channels

Television broadcasts are one of the most important information sources for individuals to both learn about a tornado threat and gather additional information and updates (Drost et al., 2016; Wolf, 2009). Drost et al. (2016) found that radar images, NWS warning messages, and meteorologist recommendations are the most preferred visual information content; with radar graphics being the most helpful. Television networks often serve as a filter between the technical messages from stakeholders, which can be less successful with inspiring the public to take protective action (Bergen et al., 2005; Drost et al., 2016; NWS, 2009). Therefore, more understanding of how people receive, comprehend, and engage with tornado warnings on television is imperative in providing effective risk information.

Another method by which individuals may be notified about a possible tornado are local outdoor sirens. These sirens, though often referred to as “tornado sirens,” are designed to alert individuals outside to seek shelter indoors from a number of different hazards. For example, the City of Dallas Office of Emergency Management (OEM) lists the following criteria for activating their outdoor sires: (1) tornado warning issued by the NWS; (2) severe thunderstorm warnings (NWS) with winds in excess of 70 MPH; (3) reports from trained storm spotters of a confirmed tornado or hail greater than 1.5 inches in diameter: or, (4) other emergency situations deemed by the OEM (City of Dallas OEM, 2020); other instances include hazardous spills or nuclear bombs. In fact, the initial purpose for the outdoor sirens—stemming from civil defense interests during the cold war—was to alert the public during a nuclear attack. It was not until the 1970s when these sirens also began to be used for environmental hazards (Coleman et al., 2010).

Research shows that outdoor sirens are one of the most relied upon

information channels for tornado warnings (Balluz et al., 2000; Brown et al., 2002; Legates & Biddle, 1999; Paul et al., 2003, 2015; Stokoe, 2016). These sources are also known as “push technologies,” since they automatically disseminate “information to the public without requiring them to seek or search for it” (Kuligowski & Kimball, 2018, p. 12). Even in the modern era where mobile phone alerts play a greater role in the warning process, Kuligowski and Kimball (2018) suggest that stakeholders continue to rely on outdoor sirens. They also suggest guidance following the PADM, in that outdoor sirens must be supplemented with additional information through other push notification systems and television/radio broadcasts.

Similar to outdoor sirens and television broadcasts, mobile phone alerts represent another type of push technology for people to learn about a threat without seeking out information. Mobile phones include both smartphones with internet capabilities and traditional cellular phones with GPS capabilities. Historically, research has indicated that television broadcast alerts and outdoor sirens are the most relied upon primary information channels for tornado warnings. However, as the popularity and technological capabilities of mobile phones increase and more people stream content rather than watch live television, their role in delivering primary information may increase. In fact, Armstrong, Cain, and Hou (2020) found that social media was the preferred information source for tornado warnings over television and direct messaging with friends. While their findings from an online survey of university students may not be representative of the public in general, their results may be an early indication of an upward trend in mobile phones as a primary information source.

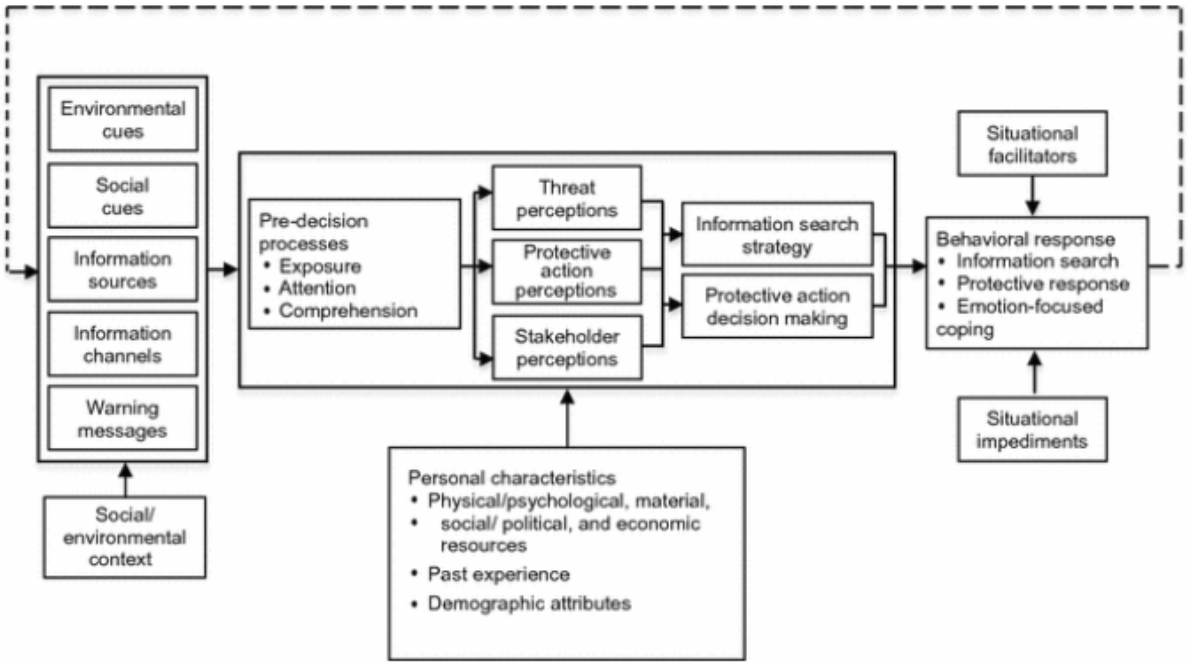
Protective Action Decision Model

To provide an operational framework for how individuals receive, interpret,

and react to environmental hazards and warnings, Lindell and Perry (2004) developed the protective action decision model (PADM), which has since been updated in 2012 (Lindell & Perry, 2012) and 2018 (Lindell, 2018).

Figure 2.1

Protective Action Decision Model



Source: Lindell (2018)

The PADM synthesizes the research on warnings into a process explaining how most people make protective action decisions by relying on information flow, and their social and environmental context (Lindell, 2018). The 2018 PADM (iteration used in this study) begins with the social and environmental contexts that exist for an individual. This stage describes the environmental (e.g., sights, sounds, smells, etc..) and social (e.g., warning, observed behavior of other, etc.) cues signifying a threat. These contexts then transition to the pre-decisional processes (exposure, attention, comprehension), perceptions (threat, protective action, stakeholder), and information search strategies and/or protective action decision-making, which may be influenced by an individual's personal characteristics (resources, experience, demographics). If

these factors satisfy an individual's decision to act the model shifts to their behavioral response, which may be affected by different situational facilitators and/or impediments. This final stage then includes a feedback loop to the beginning of the model that reflects any situational changes or new information once action has been taken (Figure 2.1; Lindell, 2018).

Contextual Cues

The PADM begins with the social and environmental context regarding a threat. Environmental cues refer to the sights, smells, or sounds that indicate that a hazard is now an imminent threat. Environmental cues that suggest possible tornado development range from a darkening sky to heavy precipitation or a condensation funnel descending from a storm. In contrast, popular myths such as green clouds signifying tornado development or the belief that tornadoes cannot cross over bodies of water or develop in mountainous regions can adversely affect one's threat belief (Ellis et al., 2019; Mitchell, 2018).

The social context described in the PADM is broader in that it encompasses observation of behaviors and response activities undertaken by other people who are in proximity to an individual, as well as the information and warning messages afforded by stakeholder organizations and through existing social networks. People who are with others before the impact of a tornado tend to have a greater forewarning and are more likely to take protective action (Quarantelli, 1988). For the warning process, developing social connections with friends and family is not only important for taking action, but it also helps to overcome any barriers in the communication of warning messages (Donner, 2007; Walters et al., 2020). This is especially important for those whose means of protective action is evacuation (Durage et al., 2014). The social and environmental context are not only critical to

the primary information one receives, but also in their process of seeking out additional information.

Decision Making

In making protective action decisions, Lindell (2018, p. 462) identifies three different psychological processes: (1) predecisional processes; (2) threat, response, and stakeholder perceptions; and (3) protective action decision-making. In the PADM, the predecisional processes are represented by exposure (receiving the information), attention (based on expectations, competing demands, and intrusiveness of the information), and comprehension (understanding the information). This part of the model brings together the social and environmental context with one's own risk perception.

Individuals are motivated to take protective action after determining that a threat is legitimate, imminent, and likely to affect them adversely. Next, an individual decides their desired protective action(s) considering the threat's probability of impact and the extent of its consequences. This process includes three steps. First, an individual identifies what protective actions are available and develops a set of possible response activities. This decision set is developed through an information search, which may include the social and environmental cues used in the evaluation of a threat, as well as an individual's personal experience with a specific hazard. Next, an individual selects the most appropriate action to take. This involves comparing the various options available according to their consequences and disruption to normal activities. Finally, once the previous two steps are completed an individual engages in the actual protective action (Lindell, 2018).

Another factor to consider in the threat evaluation process is milling (Blumer, 1939; Park & Burgess, 1924). The concept of milling describes how collectives or

groups become motivated to provide meaning and understanding to unfamiliar and unstructured situations (Turner & Killian, 1987; Wood et al., 2017). Moreover, the concept of milling aligns with the emergent norm theory (ENT), which describes how people collectively interact and create an “emergent normative structure” that influences decision-making and behavior when facing a socially disruptive event, such as a disaster (Aguirre et al., 1998). In the PADM, an information search strategy is a technique for socially confirming personal risk and consequence, and assessing if a threat is credible and justifies protective action. Regarding tornadoes, this may involve the confirmation of environmental cues by seeking out social resources. Conversely, this may involve seeking out attitude-consistent information to satisfy one’s preconceived tornado understanding, including myths or other harmful misconceptions (Lindell, 2018). One example for this is through information seeking on Twitter. Sutton et al. (2014, p. 783) found “that warning tweets are likely to focus on one or two themes at a time, rather than being complete messages.” This is important as the amount of information available through Twitter and other social media platforms may not be sufficient in motivating individuals to take immediate protective action, but rather engage in a form of “online milling.” Nevertheless, milling behavior can begin when an individual receives a warning message and may continue throughout an individual’s response process (Tierney, 2019).

Response Behaviors

Situational facilitators and impediments help to explain how people’s contextual conditions affect their ability to take protective action (Lindell & Perry, 2012). Through the lens of social vulnerability, inequities often stemming from class, gender, and race/ethnicity may influence an individual’s risk for tornado impact and magnitude of consequence or loss. Likewise, one’s environmental context may

significantly enhance or diminish their access to resources such as threat information, health care, or structural resilience. Generally, situational impediments rather than facilitators explain the variation between one's desire to take protective action the enactment of such actions themselves.

One's economic status or personal characteristics alone do not fully explain their vulnerability to tornadoes (or disasters in general). Rather it derives from multiple dimensions of social stratification and inequality. Therefore, while research indicates that certain groups may be more vulnerable to tornadoes than others, the vulnerability differences between individuals and groups manifests from the intersectionality of many different causalities of social inequity (Tierney, 2019).

Mobile home residents face a much greater threat from tornadoes (Ashley, 2007; Ashley & Strader, 2015). Moreover, the NWS (2020) conveys that "even an EF-1 tornado, typically considered a "weak tornado", will most likely severely damage a mobile home and/or roll it over." In terms of protective action decision-making, Schmidlin et al. (2009) surveyed mobile home residents and found only 31% sought shelter during a tornado warning. In a more recent study by Ash et al. (2020) revealed that 50% of mobile and manufactured home residents considered their dwellings structurally capable of protecting them from tornadoes, and of those surveyed, people with the capacity to evacuate given enough lead time did not feel the need to and those who wanted to evacuate did not have the means to. Finally, Strader et al. (2019) found that mobile home residents have fewer tornado sheltering options and live farther away from emergency services.

Other impediments to taking protective action during a tornado warning include age (elderly), economic status, and language barriers. For elderly residents, tornadoes are particularly dangerous (Carter et al., 1989; Glass et al., 1980)

because of decreased mobility, less access to warning information, and their ability to recovery from traumatic injuries (Bohonos & Hogan, 1999; Cutter et al., 2000; Schmidlin & King, 1994). Next, the Social Vulnerability Index (SoVI) synthesizes the theoretical literature on other factors such as wealth and income, gender, age, race/ethnicity, and other demographic characteristics can increase vulnerability (Cutter et al., 2003). Finally, another factor of vulnerability identified in hazards and disasters literature reflects individuals with a language barrier. For these individuals, they may be unable to comprehend warning information because of an unfamiliarity with the dominant language where they live (Donner et al., 2012). A well-known study on this conducted by Aguirre (1988) showed that because the local Spanish-language television station did not provide emergency broadcast information, it was not only the Spanish-only speaking population that was not alerted, but also people of Mexican heritage that spoke English but preferred to watch the local Spanish channel. For context, however, it should be noted that modern mobile phones often allow for a message receiver to select their preferred language. Nevertheless, outdoor public address warnings and television broadcasts do not offer the same benefits. As such, those with language barriers, or those with visual or auditory disabilities (Sherman-Morris et al., 2020), may still be impeded in their protective action decision-making.

Past research emphasizes the importance of receiving objective evidence of an imminent tornado prior to taking protective action (Comstock & Mallonee, 2005; Donner et al., 2007). This confirmation includes hearing, seeing and feeling cues from the tornado (Hammer & Schmidlin, 2002; Kuligowski, 2020; Sherman-Morris, 2010). As previously discussed, outdoor sirens and other push technologies are essential to communities as primary/secondary information sources. Many

individuals, depending on their own tornado risk perception, will continue to seek information prior to taking action. “If a threat is judged to be real and some unacceptable level of personal risk exists, people are motivated to engage in protective action search” (Lindell, 2018, p. 463). This protective action search is highly personal and shaped through individuals’ past experiences, warning messages, and their social and environmental context. Tornadoes create a particularly challenging situation for both those responsible for disseminating warning messages and those at risk. Tornado response behaviors can be vague (e.g., go to an interior room) or more complex (e.g., evacuating to a specific location) depending on an individual’s situational context.

Evolution and Criticism of the PADM

While this research thesis details each iteration of the PADM to demonstrate its evolution throughout the years and adoption to new research findings, it relies primarily on the most recent 2018 model. The original 2004 PADM focused heavily on the predecisional processes of threat belief and evaluation. In the 2012 update, the key additions were the situational facilitators and impediments that affect behavioral response and the continual information search process. By incorporating these elements, the 2012 model incorporated an individual’s pre-disaster social context as intertwined with their selection and implementation of protective action. The 2018 model, published in the second edition of the *Handbook of Disaster Research*, includes the social and environmental context with the predecisional processes, and how personal characteristics affect protective action decision-making (Rodríguez et al., 2018). Unlike the first two versions of the PADM, the 2018 adaptation emphasizes the role of demographics, social inequities, and past experiences with one’s decision-making process, which are key aspects that

influence the current project's research design. Furthermore, the 2018 model better incorporates the theoretical paradigm of social vulnerability as interwoven with the risk reduction perspective in protective action decision-making. Both perspectives may have played a role in the high degree of loss yet relatively low instances of injury or death during the 2019 Dallas Tornado.

The PADM is widely recognized among the disaster science community because of its versatility and application across various hazards and research methodologies. Despite its popularity, one criticism of the model is that studies focus on its specific phases, rather than its theoretical foundations or its entire process of information flow. For instance, the PADM fails to account for the emotional factors that influence decision-making in stressful situations such as flight or panic (Tierney, 2019). While this may be true, disaster research also recognizes that unregulated behavior or panic are extremely rare (Johnson, 1987; Quarantelli, 1999), and that it would be difficult for a warning message to incite such a response (Quarantelli, 1990). In fact, most people's initial response to a warning message is disbelief, with some continuing normal activities, however many still do seek out additional information from environmental or social sources (Lindell, 2018; Perry et al., 1981).

Although other studies and models conceptualize the protective action decision-making process, they often focus on specific hazards and situations. In particular, hurricane evacuation decision-making is a popular topic of analysis utilizing the PADM (Huang et al., 2012, 2016; Lazo et al., 2015; Rickard et al., 2017). Additionally, other conceptualizations of the PADM have examined extreme events such as pandemics (Johnson, 2019), wildfires (Strahan & Watson, 2019), and the impacts of air pollution (Liu et al., 2019) and climate change (Esplin et al., 2019). Regarding the similar models developed in disaster research, one example is the

Kyne-Donner model, which is consistent with the PADM regarding the roles of social and environmental context and information seeking, but differs in its concentration on the influence of authority recommendations with hurricane evacuation decision-making (Kyne & Donner, 2018).

This study uses the 2018 PADM as a framework to learn how people made protective action decisions during this tornado, as well as the social and environmental factors that may have influenced their decision-making processes. By doing so, this study examines how survivors of the 2019 Dallas Tornado progressed through the model rather than focusing on a single model element. Further, this study's design allows for examination of the reasons why individuals may or may not have engaged with certain elements of the PADM.

CHAPTER 3

METHODS

Research Design

The goal of this study was to uncover deep and complex meanings from participants about their personal experiences and viewpoints, and through their collective interpretations, to understand decision-making during the 2019 Dallas Tornado. Participant interviews served as the primary data to elicit information on each element of the decision-making process: threat evaluation (RQ1), response actions (RQ2), and changes in risk perception resulting from the experience (RQ3). Once the data were collected, a constant comparative analysis method was applied to identify collective themes about protective action behaviors during this event. The purpose for this analytical approach was to allow common themes to emerge during the data collection period. Once all the data was collected and transcribed these themes were reevaluated for confirmation. Additionally, this constant comparative approach helped determine when saturation was achieved.

Data Collection

Study Area

The recruitment area for this study included any location affected by the EF-3 tornado that struck Dallas, Texas, on October 20, 2019 (Figure 3.1). Specifically, the participants of this study resided in the Preston Hollow neighborhood in the north central region of the city.

Figure 3.1

2019 Dallas Tornado Path

Data Obtained from Earthstar Geographics, Texas Parks & Wildlife, ESRI, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, NOAA, City of Dallas GIS, and Census Bureau's API for American Community Survey.

Participant Recruitment and Sampling

The population for this study consists of individuals over the age of 18 and who lived in the area affected by the 2019 Dallas Tornado. Participants were recruited through a private Facebook group of tornado survivors. By purposive recruitment through this method, along with subsequent snowball sampling, it enabled sampling a diverse group of participants who had direct experience with this tornado. Once the student investigator was accepted as a member of the private group *Dallas Tornado People 2019*, a post was made to the wall for all members to see that briefly explained the project with contact information for those interested (see Appendix B). Posting on the message board yielded 10 responses and 12 more interviews were conducted through both snowball methods from previous interviews and one final post near the end of the data collection phase.

The average age of participants was 58.3 years with a majority being female (*n* = 18). A little more than half reported having a pet (i.e., a dog or cat) in the home (*n* = 12). Only 8 participants had children under the age of 18 in the home at the time of the tornado (*n* = 15, not having children home), however two participants had more than one child at home. There were 13 participants living in a condominium (the same complex) and 10 living in a house. Participants varied as to whether they were home alone (*n* = 9) or with others in their residence (*n* = 14) when the tornado struck. The greatest discrepancy found among participants was that only 4 reported having direct experience with a tornado prior to this event, with the remaining 19 describing a variety of indirect experiences. However, because the path of the Dallas Tornado moved across an area that was, in general, homogenous in race/ethnicity and economic characteristics, these attributes were not included in the demographics gathered during the interviews. (see Table 3.1, Figure 3.2).

Interviews

Once it was determined that the individual met the study's criteria, a date and time for a phone interview was established. Prior to conducting each interview, the student investigator offered to send a PDF copy of the study's recruitment flyer and obtained verbal consent. Each interview was conducted loosely following a predetermined interview guide (see Appendix A). Interviews took place between June and October of 2020, all within a year of the 2019 Dallas Tornado. In total there were 22 interviews and 23 participants, this was because one interview was conducted with a husband and wife, however both provided individual responses to each interview question. The shortest interview lasted 18 minutes and the longest was 91 minutes, however most interviews lasted approximately 45-60 minutes.

Table 3.1

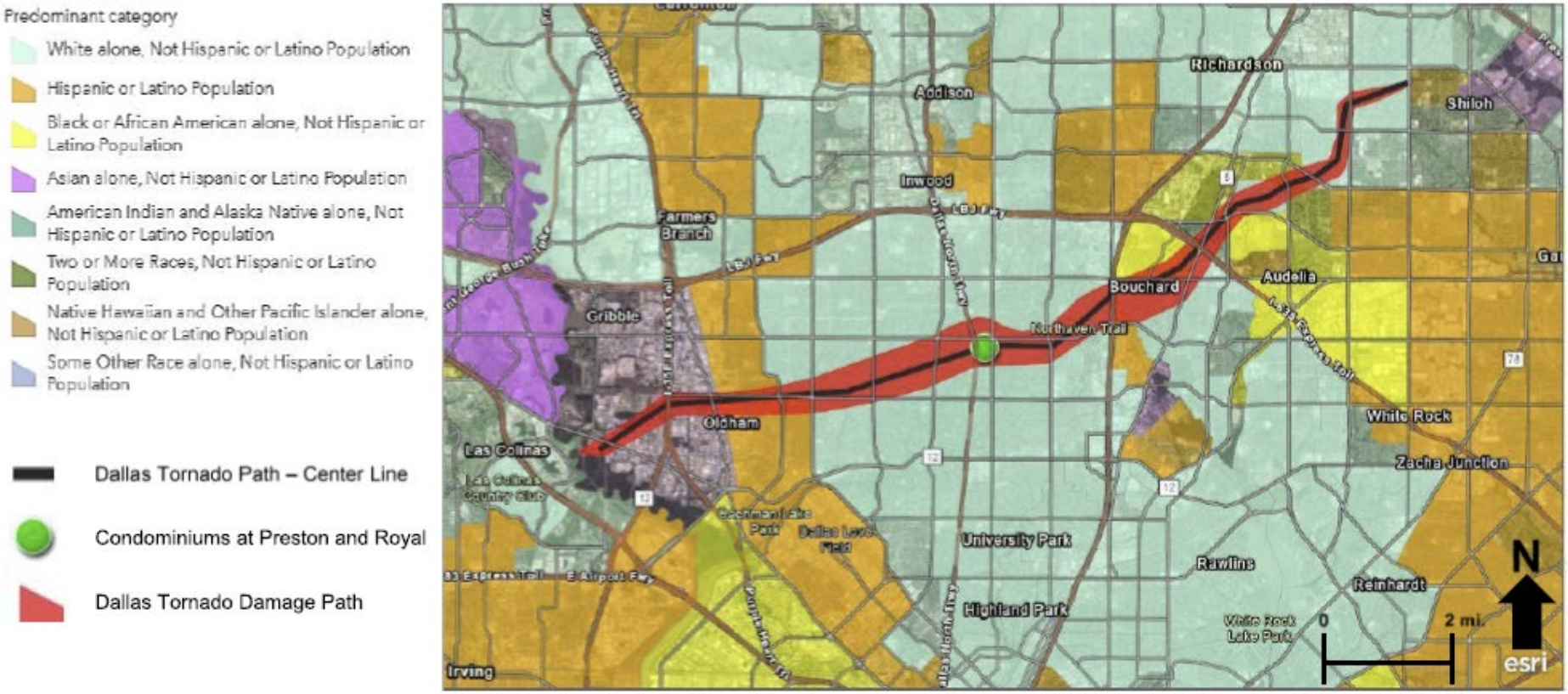
Participant Demographics

Part. #	Age	Gender	Education	Pets (Y/N)	Children under 18 at Home (Y/N)	Own Home (Y/N)	Condo. Resident (Y/N)	Living with Others (Y/N)	Direct Tornado Experience (Y/N)
1	68	F	Graduate Degree	N	N	Y	N	Y	N
2	63	F	Some College	Y	N	Y	N	Y	N
3	42	F	Graduate Degree	Y	Y*	Y	N	Y	Y**
4	51	F	Graduate Degree	N	N	Y	N	Y	N
5	55	F	4-year Degree	Y	Y	Y	N	Y	N
6	38	F	4-year Degree	Y	Y	Y	Y	Y	N
7	68	F	4-year Degree	N	N	Y	Y	Y	N
8	59	F	Some College	N	N	Y	Y	N	N
9	53	F	Graduate Degree	N	N	Y	Y	N	N
10	48	M	4-year Degree	N	N	Y	Y	N	N
11	58	M	Graduate Degree	N	N	Y	Y	N	Y
12	56	F	Graduate Degree	Y	N	Y	N	Y	N
13	76	F	Graduate Degree	N	Y	Y	Y	N	N
14F	61	F	Some College	Y	Y	N	Y	Y	Y**
14M	57	M	Some College	Y	Y	N	Y	Y	N
16	74	F	Graduate Degree	N	N	Y	Y	N	N
17	77	F	4-year Degree	Y	N	Y	Y	N	N
18	62	M	Graduate Degree	Y	N	Y	Y	N	N
19	56	M	Some College	Y	N	Y	Y	N	N
20	41	F	4-year Degree	Y	Y	Y	N	Y	N
21	62	F	4-year Degree	Y	N	Y	N	Y	N
22	38	F	Graduate Degree	N	Y*	Y	N	Y	Y**
23	76	F	Some College	N	N	Y	N	Y	N
	Avg 58.2	F = 18 M = 5	Some College = 6 4-year Degree = 7 Graduate Degree = 10	No = 11 Yes = 12	No = 15 Yes = 8	Rent = 2 Own = 21	Condo = 13 House = 10	With Others = 14 Alone = 9	Indirect = 19 Direct = 4

*Denotes more than one child under the age of 18 in the home. **Denotes direct experience with a tornado without damage to the structure where they sheltered.

Figure 3.2

Dallas Tornado Path and Predominant Race/Ethnicity by Census Tract



Data Obtained from Earthstar Geographics, Texas Parks & Wildlife, ESRI, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, NOAA, City of Dallas GIS, and Census Bureau's API for American Community Survey.

The interview questions (IQs; see Appendix A) encouraged participants to chronologically and meaningfully reflect on their experiences during the 2019 Dallas Tornado. The first section of the interview guide (IQs 1-5) focused on participants' experiences of the tornado event (RQs 1 and 2) and coincides with steps in the PADM. These questions asked participants about the social and environmental context (1) and their pre-decision processes after they learned of the threat (2a). The next questions (2b and 3) addressed participant's perception of threat, protective action options, and external stakeholders, as well as if they initiated any information search strategies (4a) at this point during the event. IQs 4 and 5 concentrated on the actual response activities undertaken and what may have facilitated or impeded these behaviors. The second part of the interview guide (IQs 5-7) built on participant's previous answers to learn how this tornado will likely affect their decision-making in the future (RQ 3). The final questions in the interview guide (8 and 9) allowed participants flexibility to add to their narrative of the event and to gather demographic data for analysis and theme comparison. The interview guide and questions used in this study are open-ended and encouraged participants to discuss this tornado in-depth. Additionally, the IQs are loosely in chronological order of the PADM, yet a semi-structured design was implemented to allow the student investigator to adjust their sequence according to the specific context of each interview (Phillips, 2014).

Data Analysis

After each interview was completed, it was transcribed and analyzed through inductive coding and a constant comparative approach. This process involved comparing and aggregating different segments of the data according to similar characteristics and sorting them into temporary categories to uncover emerging

themes (Connaway et al., 2017). By analyzing the data simultaneously with collection it helped determine with greater accuracy when saturation was reached (Miles & Huberman, 1994). An open coding process was used to identify common themes within the data. An inductive analysis approach allowed for participant meanings and experiences to guide the themes of this study (Terrell, 2016).

The coding process occurred in four rounds to determine what themes emerged and then to winnow them down. The first round took place after each interview was transcribed and relied on the interview questions to serve as a codebook. Because the interviews were semi-structured some of the answers provided by participants strayed off topic. The purpose for this round was to distinguish between what parts of the interview were relevant to the concept of this research. The second round took the answers for each interview question and coded them according to where they applied across the PADM. This helped in assigning a loose chronologic order to their decision-making process during the night of the tornado. By laying out participants' experiences chronologically it allowed for themes in their decision-making processes begin to emerge. The importance of this was also because participants frequently provided long answers to many of the interview questions and remembered specific details about their decision-making process as the discussion progressed. This round facilitated in taking these details and realigning them with previously answered questions. The third round of coding took the data in chronologic form and applied it to the research questions of this study. This was necessary as many of the answers provided by participants could be applied to both RQ1 and RQ2. For example, many of the social and environmental cues that affected their threat belief and evaluation processes were also situational facilitators or impediments. Unlike the first three rounds of coding, the fourth round

took place after all interviews were conducted and transcribed. In this final round, the aggregate data from all the audio-recordings and transcriptions was reexamined to ensure that the themes that emerged remained consistent throughout the data collection process. Additionally, this allowed for the student investigator to examine each interview recording and transcription in its entirety to verify that no details were missed during the first three rounds of analysis. Ultimately, by coding the data in this manner it allowed for each participant's experience to be expressed in a similar pattern, which enabled the common and consistent themes to emerge during analysis.

CHAPTER 4

RESULTS

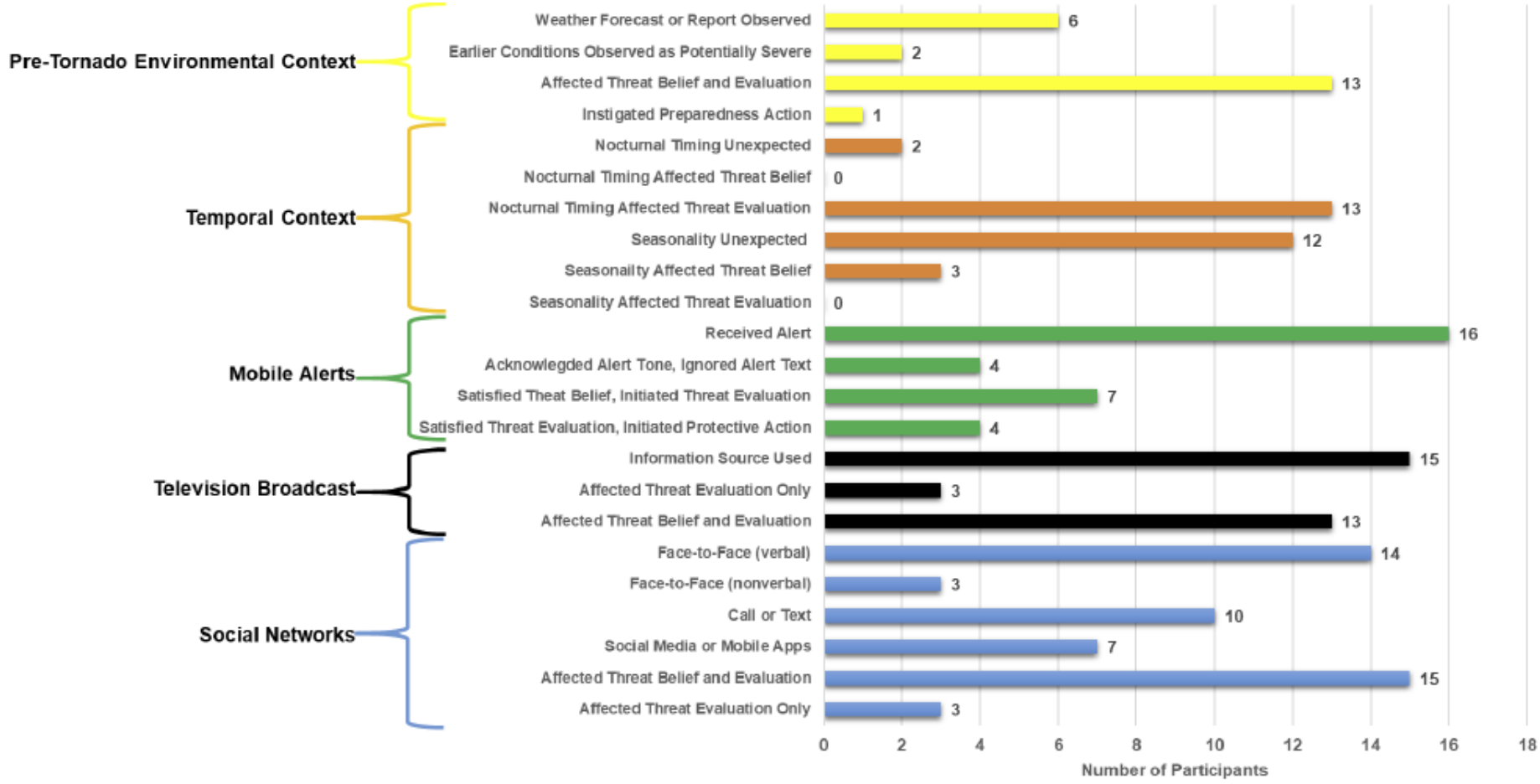
The results of this study provide insight into individual's protective action decision-making during the 2019 Dallas Tornado. The first research question asks about the social and environmental context and about factors affecting individual's threat beliefs and evaluation processes. The second research question investigates the situational facilitators and impediments included in the PADM and how these aspects applied to both the protective action decision-making processes and ultimate protective actions undertaken by people who experienced this tornado. The final research question asks how this tornado experience affected individual's anticipated protective action decision-making process for future tornadoes. The following subsections, organized by research question, present the common themes that emerged from the interviews and how they relate to the PADM.

RQ1: Factors Affecting Threat Belief and Evaluation

There were five common factors that emerged during the interviews concerning participant's threat belief and evaluation processes (Figure 4.1). The first factor was the pre-tornado environmental context that offered little indication of the potential hazard, so participants had to rely on information about the tornado once the threat had already developed. The second factor was the temporal context of the tornado. Participants viewed nocturnal timing of this tornado as unremarkable, but they discussed how decreased visibility affected their evaluation processes. Comparatively, the seasonality of this tornado was unusual to participants, however, it did not appear to have the same effect on their threat appraisal. The third factor brought forth by participants was how the tornado alerts received through mobile devices influenced their threat belief and evaluation processes.

Figure 4.1

Factors Affecting Participant's Threat Belief and Evaluation



More specifically it was both the warning message tone and verbiage affecting their threat belief and threat evaluation processes. The fourth factor was that television broadcasts were a common information source among participants, but were most effective as a supplemental source after learning about the threat from elsewhere. Specifically, this information source provided them with desired geospatial information when their primary notification channel did not. The fifth and final factor that emerged were the social networks—including face-to-face interactions and mediated communications—that affected participant's threat belief and evaluation processes throughout the event. These five factors surfaced throughout the interviews as having a direct influence on threat belief and evaluation.

Pre-Tornado Environmental Context

Participants generally expressed confidence in their ability to recognize a tornado threat and discussed their meteorological observations and the information learned from weather forecasts earlier that day. For the most part, participants noted a lack of meteorological conditions associated with severe weather or tornadoes prior to the event, with two recalling a heightened level of awareness because of their observations. Similarly, only six participants were aware of the severe potential based on local forecasts. The common sentiment conveyed by participants was that neither severe weather nor tornadoes were expected that evening, much less at their location.

When discussing the meteorological observations earlier in the day, participants consistently referred to how pleasant the weather was outside. Moreover, participants felt knowledgeable about the local climate and were familiar with the typical conditions preceding severe weather outbreaks or tornadoes. "When there is bad weather we do pay attention, but it happened very quickly and there

wasn't really bad weather" (Participant 12). Participant 4's experience before the tornado was more striking:

> I don't remember having any indications that a tornado was even a possibility. I mean really, we had 35 people outside of our house before the storm. If I had thought that there was any danger, we wouldn't have had the gathering. We had no idea. I just remember it being really humid, it was like super humid and super sticky, but I don't remember there being bad winds [or] dark clouds. (Participant 4)

In the hour leading up to the tornado, other participants who were outside did recall seeing some weather abnormalities, but nothing that increased their risk perception for tornadoes. "The clouds looked really weird but they weren't funnel clouds, but they were super funky and it was really quiet—no rain, no nothing. So there wasn't really much that you could look for" (Participant 21). Out of the 23 interviewees, only Participant 18 discussed taking any sort of preparedness action prior to the tornado, "the sky looked promising for some sort of storms, so I moved my car undercover." In this context, however, the preparedness activity was out of concern for the possibility of large hail. Additionally, since this was a nocturnal tornado the environmental observations just prior to the storm's impacts were scarce, placing a greater emphasis solely on the information participants gained through the media and forecasts. Consequently, both a lack of meteorological observations and knowledge of severe weather forecasts were detrimental for participant's threat belief and evaluation processes.

Temporal Context of Dallas Tornado

This tornado event's seasonality and time of day contributed to surprise among participants, since tornadoes were more commonly associated with spring and summertime afternoons. Instead, participants experienced a nocturnal October tornado. "I would never have expected to have gotten them in October. I was

shocked, I think that's why I went to verify because that was like, really?" (Participant 3). Likewise, Participant 10 voiced their surprise for the seasonality of this tornado, "usually our stormy weather in Texas is in the Spring, we get some pretty hellish storms in March and April. In October it's really just kind of drizzly sometimes." Although participants were cognizant of the tornado risk year-round (often referencing the 2015 tornado in December that hit nearby Garland/Rowlett), the unexpected occurrence of this tornado in October was a factor that affected their threat belief.

Comparatively, the nocturnal development of this tornado had a stronger effect on their threat evaluation. In other words, because this tornado developed just after nine o'clock when it was dark out, this thwarted their expected and preferred evaluation processes.

> At nighttime it's almost impossible, I mean I've never been in a tornado at night, but in the daytime I mean, you know, you go out and you look for the wall clouds and you look for the green tinge in the sky, and you look for very strange thunderstorm warnings, and that makes it more real. (Participant 20)
>
> I watch, you know if something looks ominous. This is only if it's daylight, at night you can't really see anything, but during the day the sky can be a green color. I've seen that before when there's been tornado-type activity. Also, just look at the clouds and the shape of them, and if they're swirling or low or anything like that. (Participant 2)
>
> Usually we would go outside and kind of see what's going on. We would just watch the clouds, see which way they're moving. (Participant 3)

The key term here that participants articulated was "usually" (or similar), when asked about their decision-making processes and environmental cues. If the tornado had occurred during the day, they normally would have gone outside to confirm the threat from ominous or deteriorating conditions. Therefore, the temporal context of the 2019 Dallas Tornado affected both participants' threat belief (seasonality) and evaluation (nocturnal timing) processes.

Mobile Weather Alerts

The mobile alert's tone and text components elicited different response behaviors among participants, affecting both their threat belief and evaluation. All 23 interview participants owned or had access to a mobile phone or smartphone at the time of the tornado, with 16 having received a mobile alert. For some (*n* = 4) the mobile weather alert alone was enough to encourage protective action, and for others it led to seeking out more information (*n* = 7) to further evaluate their risk (Table 4.1, Figure 4.2). The tone accompanying the alert prompted participants to immediately look at their phone, even if just to silence it. Only four participants reported hearing the tone and elected to ignore it, without reading the text. For participants who did read the text accompanying the alert (*n* = 12), they felt the verbiage was clear, concise, and urgent in nature. In general, the combination of the mobile tone and text satisfied participants' threat belief. In the context of the PADM, the mobile phone alerts satisfied the pre-decisional processes of exposure, attention, and comprehension those who engaged fully with the alert.

Table 4.1

Participant Interaction with Mobile Alerts

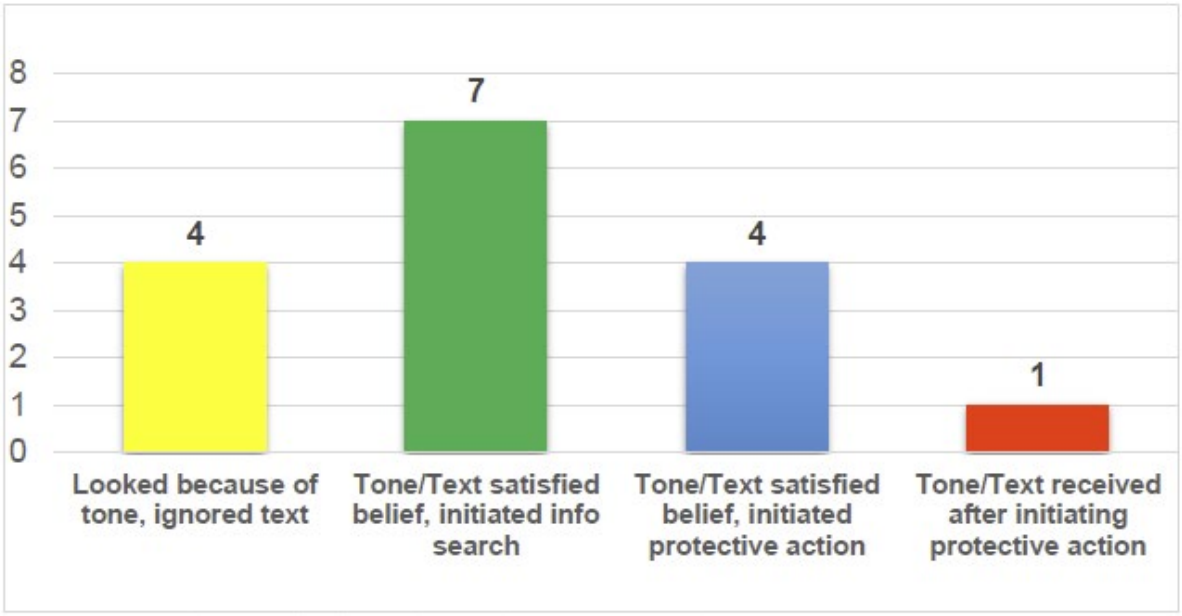
Participant	Received/ Interacted with Mobile Alert	Response to Mobile Alert
1	Yes	Looked because of tone, ignored text.
2	Yes	Tone/Text satisfied belief, initiated info search.
3	Yes	Tone/Text satisfied belief, initiated info search.
4	Yes	Tone/Text satisfied belief, initiated info search.
5	Yes	Tone/Text satisfied belief, initiated protective action.
6	No	Does not remember receiving mobile alert.
7	Yes	Tone/Text satisfied belief, initiated protective action.
8	No	Does not remember receiving mobile alert.
9	Yes	Looked because of tone, ignored text.
10	No	Does not remember receiving mobile alert.
11	Yes	Tone/Text satisfied belief, initiated info search.
12	Yes	Tone/Text led to milling behavior.

(table continues)

Participant	Received/ Interacted with Mobile Alert	Response to Mobile Alert	
13	No	Does not remember receiving mobile alert.	
14F	Yes	Looked because of tone, ignored text.	
14M	Yes	Looked because of tone, ignored text.	
16	Yes	Tone/Text satisfied belief, initiated protective action.	
17	Yes	Tone/Text satisfied belief, initiated protective action.	
18	No	Does not remember receiving mobile alert.	
19	No	Does not remember receiving mobile alert.	
20	Yes	Tone/Text satisfied belief, initiated info search.	
21	Yes	Tone/Text received after initiating protective action	
22	Yes	Tone/Text satisfied belief, initiated info search.	
23	No*	Does not remember receiving mobile alert.	
Total	16 (Yes) 7 (No)	Looked because of tone, ignored text	4
		Tone/Text satisfied belief, initiated info search	7
		Tone/Text satisfied belief, initiated protective action	4
		Tone/Text received after initiating protective action	1

Figure 4.2

Participant Interaction with Mobile Alert Tone



Interaction with mobile alerts necessitates that people have the capacity to hear these alerts and understand the information they provide. The audible tone that accompanied the mobile alert was effective in capturing participant's attention. They

noted how the sharp tone led them to immediately engage with their mobile device even when they were unaware of the alert's purpose. Participant 7 recalled how the volume of the tone was unlike the typical noise accompanying typical text messages or calls, "It was like an emergency alert, like a really loud emergency alert on the iPhone that says there's a tornado… It was pretty obvious and it was pretty loud." Terminology such as sharp, piercing, and even annoying was a common way that participants described the warning tone.

> We had no idea until my phone, that alarm from the National Weather Service came on my phone, what makes that annoying sound, so I just shut it off real quick, but I caught a glimpse of the word "Warning", so I turned it back on to see what it said, and it said "Severe" or "Tornado Warning." (Participant 2)

Every participant who fully engaged with the mobile alert noted that they trusted the information about a possible tornado threat that was sent directly to their phones. The information about the tornado threat was brief, such as "Tornado Warning, Take Shelter Now", or similar. The commonality among these participants (n = 11) was that mobile alert satisfied their threat belief.

> It said tornado warning immediately, and I had never gotten a text, like a weather text about a tornado. So I was like "this looks serious!" When it said that, when I saw that and it said "Take Cover Immediately" I thought crap, let me figure out where this [tornado] is and how far away it is. (Participant 3)

> All of a sudden we got a text, it was different from any other text we've ever had. We always get text that says "oh tornado warning until 9:00 o'clock tonight or something," but instead it said something like "tornado take cover now!" When it said take cover now that scared me because we've never had one that said take cover now. (Participant 5)

The use of strong, attention-grabbing language helped individuals understand that this tornado was a unique and dangerous situation. Participants in this study frequently brought forth that terminology such as "severe" and "immediate" circumvented any potential confusion between tornado watch and tornado warning.

In the context of the PADM, mobile alerts are a central theme that emerged from this study because every participant had the opportunity to receive them (exposure), and for those who did, they were deemed a credible information channel. Additionally, the tone captured their attention, while the clear and concise language satisfied their comprehension.

Television News Broadcasts

Television news broadcasts emerged as a factor affecting threat belief and evaluation in two ways: in apprising environmental conditions before the event and in confirming the tornado threat once the tornado was already on the ground. Along with participant's meteorological observations, the information obtained through the media and weather forecasts did little to invoke a belief there was a tornado threat in the area. As Participant 3 recalled, "I didn't even know that there was rain in area. I just didn't think there were supposed to be storms, or I just remember thinking they weren't calling for tornadoes earlier in the day." Even when participants recalled seeing forecasts predicting severe weather, it was not perceived as a threat to their specific location. As Participant 9 described, "I watched the news that night and they had said that bad news was going to be north of Denton, which is pretty far from where I live… I knew it was going to rain but I wasn't really worried about it." Participant 23 added to this by noting, "We didn't know anything about all this bad weather. If we had heard any rain or anything… We would have been downstairs with [our neighbor]." This illustrates how a lack of information regarding the potential for severe weather on the news has implications on people's threat belief and evaluation processes they typically would engage with.

When the tornado threat was developing, participants expressed that only seeing a running ticker with the type of threat and county was insufficient for their

threat belief and evaluation processes. Instead, participants discussed their familiarity and trust in a particular meteorologist as a major factor that affected their threat belief and evaluation processes.

> The weatherman was very good at communicating data that he was looking at that led them to believe and know that it was a confirmed tornado on the ground. He talked about the cloud of debris and how high it was in the air, he said that does not happen unless it is a confirmed tornado that has touched down… He stated those facts and that helped in our brains to really wrap around. (Participant 20)

> The weatherman was looking at it [and] they have a hook echo on their radar screen, and he said that this looks like it's real. About a minute later he said "OK we have spotted it on the ground near Love Field" and the direction it was heading… He's actually a tornado chaser, so he was the best person ever to be talking about it because he pinpointed it exactly where it was and saying "Y'all take cover!" and he was just so serious. (Participant 2)

As Participant 2 touched on, the meteorologist specifically noting that the tornado was spotted near Love Field, which fulfilled their evaluation process. Participants expressed that seeing radar overlain on maps with familiar locations (e.g., Love Field, Interstate 35, etc.) was the most helpful visualization provided. Participant 4 spoke to the importance of spatial information noting, "we just got a text to our phones… So I was like turn on WFAA [local TV network]. Right away we turned on Pete Delkus and saw the tornado was at the airport heading Northeast, and it was at Preston and Royal I think." Additionally, this example shows how trust in a meteorologist and geographic context were intertwined regarding their threat evaluation. Participant 20 discussed how they were watching a television broadcast that communicated the tornado threat as a scrolling ticker. To gratify their desire for evaluating the threat further, they switched to a channel that provided complete coverage of the event. "I switched it to the other news broadcast and they had already started interrupting their broadcast with the weather report, so we switched it to that and they were talking about this confirmed tornado." For Participant 20, their

threat belief hinged on the confirmation of the tornado from a recognized the trusted source.

Social Networks

The role of various social networks available to participants was another factor relating to their threat belief and evaluation. The most common social networks included communicating with others in proximity, accessing online social networks, and information received from others via call or text. These resources include both the networks that participants sought out and those that provided information without query. Furthermore, each of these three resources emerged as factors that affected participants' threat belief and/or evaluation processes.

Face-to-face communication with other people (same residence or neighbor) was a social factor available to participants (n = 14, with 13 participants living with others and 1 engaging with neighbors before taking action) either in place of, or alongside with technological resources. Although each participant's living situation differed, they collectively discussed how communication with others near them was a factor that affected their threat belief and evaluation processes. "I was watching Netflix I think, something on my computer with my ear plugs in and I think it was around 9:00. My daughter came in and told me the sirens were going off, and I couldn't hear them. I didn't hear them until I took out my ear buds and sure enough they were going off" (Participant 6). In this case, the information provided by the participant's daughter satisfied their threat belief and evaluation and instigated their protective action response. Conversely, Participant 12 was with their daughter when they both learned about the tornado and expressed a different threat belief and evaluation process.

I was sitting in the kitchen with my daughter and the alarm on my phone went

> off. So, she said, “what do you think about this?” and I said “well, I don’t know” … Usually if something bad is happening, my husband’s really into the weather, so we just kept chatting, but we didn’t take action. Then, all of a sudden, my husband came running down the stairs looking at his phone. So I said to my daughter “get in the closet!” I knew, because I know what he looks like, and he looked very serious and panicked. Then I knew we were in trouble. (Participant 12)

While communication with those in close proximity was a factor for both Participant 6 and Participant 12, the effect on their threat belief and evaluation processes differed. For Participant 6 verbal communication was enough to initiate protective action, whereas the non-verbal cues of Participant 12’s spouse elicited this response. Participant 10, a condominium resident who was home alone, revealed how their preexisting relationship with neighbors affected their threat evaluation process.

> I opened up my [front] door and then I could see the two [neighbors] that are living upstairs come running down and screaming “[downstairs neighbor’s name]” who is across the hall, and so all at the same time everyone opens up their door and the lady across the hall goes, “You get in here right now!” (Participant 10)

Additionally, mediated communication through phone calls and text messages influenced participant’s threat appraisal, especially among those who were home alone at the time. For Participant 8, receiving a phone call was the resource that confirmed their threat belief and instigated protective action after other social and environmental cues had failed to do so.

> My daughter called about 5 minutes before the tornado hit and she was very calm and said, “what are you doing?” I said, “watching TV,” and she said, “well you know there’s a tornado in your area,” and I said, “you know we’ve been getting all these weather reports but I’m not really worried about it.” She said, “Well it looks like it’s coming your way so you might want to take cover,” and I’m looking out the window and she says “no mom seriously you better take cover.” (Participant 8)

> My sister, who lives across the street from an air traffic controller, called me to tell me that we are going to get hit. There was nothing coming across the TV, and the alert on our phones didn’t come off until about four minutes after I had already talked to my sister… Well she was just real concerned. She said “You’ve got to take cover.” So we got the dog and us and went into the closet

> behind out fire place and that's where we were the whole time. (Participant 21)

The role of mediated communication and threat appraisal continued even after participant's took protective action. In these circumstances, the information provided by social networks may have otherwise been unavailable to those sheltering in their closet or bathroom.

> I was deep into the closet, and at that point quite a few of my friends started texting me and saying "take cover there's a tornado heading your way!" I'm in this text group, and one of the friends sent a picture of the sky, saying "I've never seen a sky like this. It's beautiful, look at the sky." (Participant 12)

Here, the information that Participant 12 received served as means for them to confirm the threat of a tornado and to continue taking shelter. The same scenario was reflected by Participant 7, "I took my devices in with me and I was texting the whole time with my daughter in Austin and a friend who was in Highland Park, and they were able to kind of keep us a little bit posted on what was going on." The experiences described above show how the information provided through preexisting social networks can facilitate in implementing protective action, function as a source to confirm the threat, and increase situational awareness throughout the entire protective action decision-making process.

The most popular social media platform participants discussed was Facebook. This resource, compared to mobile weather alerts, for instance, reflected a threat evaluation process where participants sought out information on their own accord. "I jumped on social media because I thought of some of them, like the NWS, Pete Delkus, [and] some of the big weather people. So, I jumped on social media to figure out what was happening, and I saw that the tornado was at Love Field" (Participant 3). Similarly, Participant 4 noted that Facebook was an effective tool because of their familiarity with information seeking on the platform. "I've done

Facebook live before from WFAA. It would have to be somebody local I trusted, not like Weather.com or something. I check there for the temperature but not for an emergency" (Participant 4).

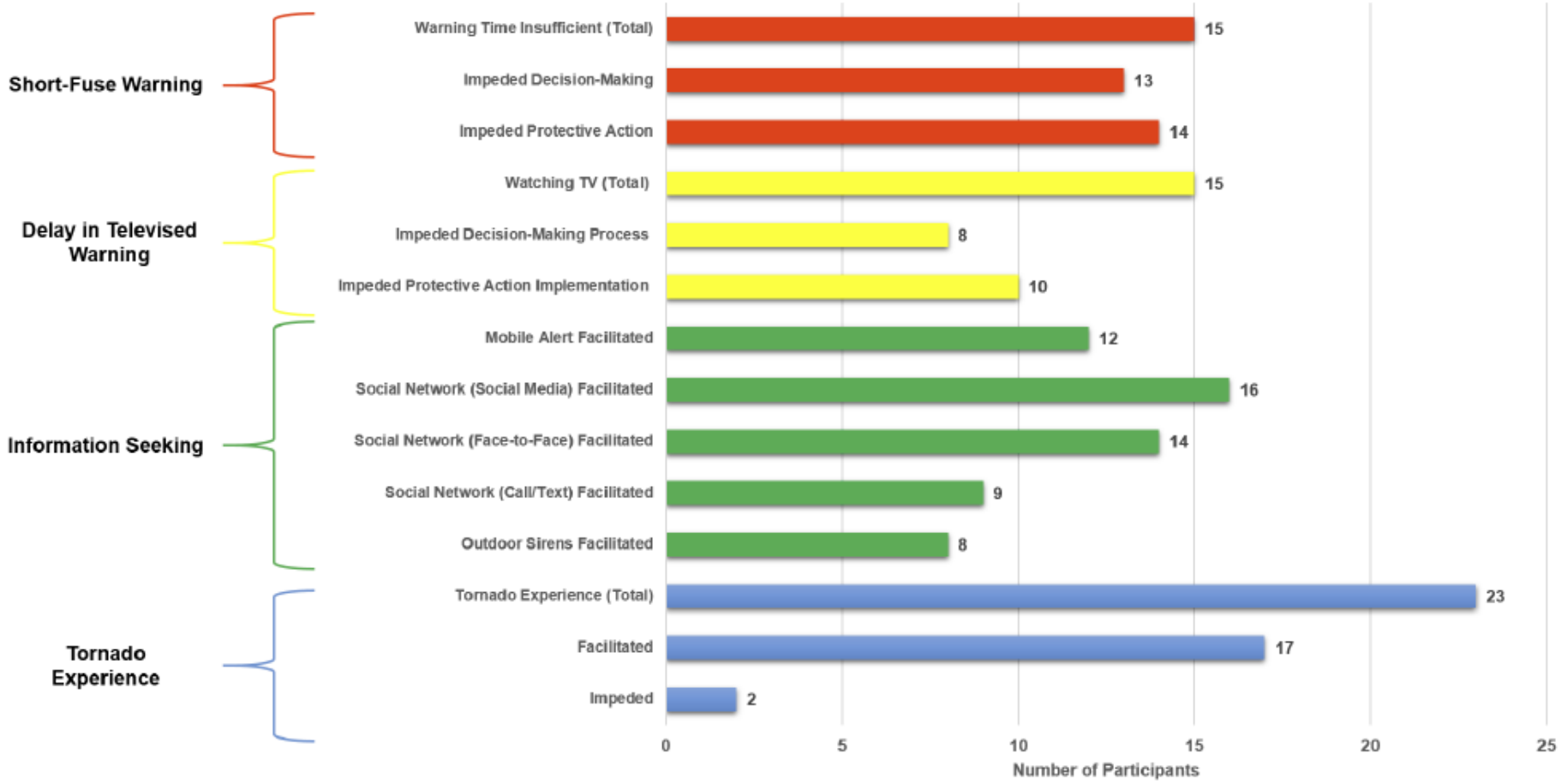
Along with the social media pages for trusted stakeholders, Facebook pages for hobbyist groups were also discussed. Participant 14M, an amateur radio (ham) operator, accessed the Facebook page for a group of storm chasing amateur radio enthusiasts and was able to passively stream and listen to information about the tornado while sheltering in the bathroom, "There's a couple different [Facebook] groups out there, so at that point once we were getting notified that this was getting serious we went ahead and turned that ham radio on [through Facebook group], and at that point we were streaming up to the minute when it got us" (Participant 14M).

RQ2: Facilitators and Impediments to Decision-Making and Action

Four factors shaped decision-making and action among interviewees, two of these factors functioned as impediments while the other two served as facilitators. The first and most common impediment that participants spoke of was the minimal amount of time between their initial alert to a threat and the tornado, which for two participants the physical impact was the initial alert. The second impediment was communicated by participants watching television at the time of the tornado (n = 15). Specifically, participants watching the Dallas Cowboy's game (n = 7) expressed how a delay in interruption (or lack thereof) impeded their threat belief and evaluation processes, as well as their protective action implementation. The first facilitator that emerged during the interviews was the capacity participants had to seek out additional information though mobile devices (e.g., social networks, peers, mobile apps) and television networks covering the tornado. The last factor that surfaced as a facilitator among participants was their knowledge and experience with tornadoes.

Figure 4.3

Impediments and Facilitators to Protective Action Decision-Making and Implementation



Tornado experience among participants ranged from surviving a tornado event to participating in tornado drills, experiencing tornado warning events, obtaining knowledge of other tornado disasters from media coverage, or learning about the experiences of others in their social networks.

Tornado Warning Lead Time

The short amount of time between when participants learned about the tornado and it impacted their location impeded their ability to seek out information in the way they most desired (Participants 3, 5, 23). For some (as the case for Participants 5, 16, 18), this minimal lead time impeded their capacity to achieve their preexisting plan for protective action during a tornado:

> I don't know how to work our TV. By the time I'd have figured out how to turn it on and get to the right station it would have been too late. Usually you get ample warning and we like to be weather aware and all of that. I just felt like there wasn't any of it. (Participant 3)

> I just felt like we were getting hit that minute. There wasn't time to switch channels on TV or anything. We just immediately tried to get our girls and our dog to go in the bar, which was not a good choice. (Participant 5)

> I really spent most of the time that the tornado was doing the damage in the den, actually out in the midst of it within my condo. (Participant 18)

> From the time she [daughter] got that text, and went to the window and then screamed at me and we got in the bathroom, it couldn't have been more than two minutes, if that. It all happened so quickly, and then we were just kind of in shock, we didn't know what to do. I mean, that was it. We just had to take some cover because they said it's heading our way, but we didn't know that it was already there. We didn't even have time to think. (Participant 23)

> When they turned it into a tornado warning, we actually had less than five minutes to take cover. I had agreed previously with my neighbor downstairs that when we have storms if I wanted to come down I could shelter with her. So I called her on my way down except she was across town having dinner with people. By then I could hear it. It was explosive sounding, and the door into our entryway was swinging back and forth and branches were coming in, and I realized I didn't have time to go back upstairs. So I just got under the stairwell, one of those stairways that's open. There wasn't really protection, but that was the best I could do. (Participant 16)

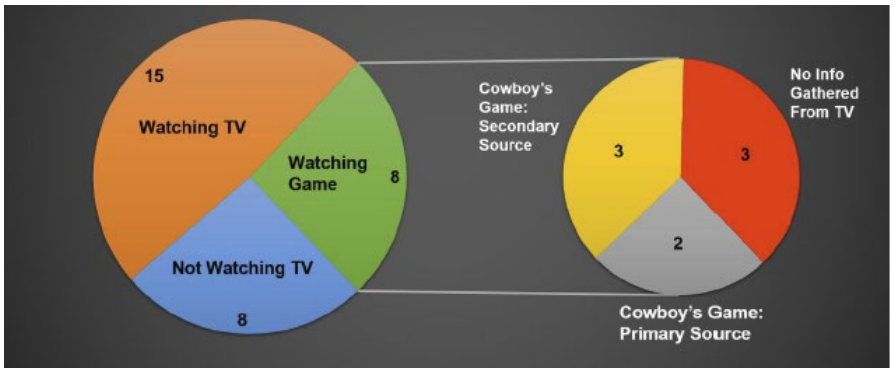
While these examples provide context to the impediment caused by a short amount of warning lead time, most participants offered simple responses to this interview question such as “it just happened so fast” or “I/We felt like we had no time.” Consequently, this impediment, depending on each participant’s unique situation, affected their decision-making, ability to take their most-desired action, or both.

Delay in Televised Warning Information

In a tornado with short-fuse warning, any delay in warning information impedes protective action decision-making and implementation. When the tornado hit, 15 participants reported that they were watching television (Figure 4.4). Despite a majority of the participants watching television, only two confirmed this to be their initial notification to the threat of a tornado, with five others reporting it as a secondary information channel.

Figure 4.4

Participants Watching TV: Use of Cowboy’s Game as Source of Tornado Alert Information



At the time when warning alerts were being issued, and the tornado was already damaging the Preston Hollow community, the Dallas Cowboy’s football game was being broadcast on the local NBC affiliate. Unlike the other broadcast networks (e.g., ABC, CBS, etc.), NBC elected to delay coverage of their tornado threat until

commercial breaks (Table 4.2). The information NBC provided was a running ticker across the top of the screen—rather than geographic visuals including radar—that provided severe weather and tornado warnings by county for the entire North Texas region.

Table 4.2

Television Coverage of the Dallas Tornado

Television Network and Coverage	Local Time (CDT)						
	9:00 PM	9:05 PM	9:10 PM	9:15 PM	9:20 PM	9:25 PM	9:30 PM
NBC (KXAS-TV)		9:06 PM*		9:13 PM*		9:23 PM*	
CBS (KTVT)				9:13 PM			
ABC (WFAA)							
FOX (KDFW)							
Tornado Information	Tornado on Ground (8:59 PM); NWS Issues Tornado Warning (9:02 PM)	Tornado on Ground (Radar); EF-3 Magnitude Reached	Tornado on Ground (Radar)	Tornado on Ground (Radar)	Tornado on Ground (Radar)	Tornado on Ground (Radar)	Tornado Dissipates (Radar)

Key: No Coverage | Ticker on Screen | Interruption during Commercial | Full Coverage

*Denotes a commercial break, with full coverage of the tornado lasting about 60 seconds.

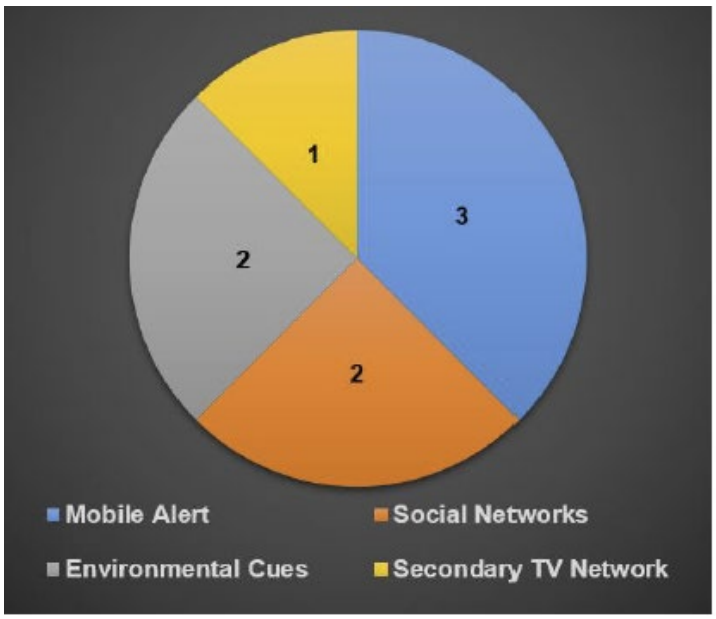
Out of the 15 participants watching television, eight were watching the Cowboy's game. Moreover, every participant watching the game expressed how the delay in full coverage impeded their protective action decision-making and implementation. Of these eight participants watching the game, five reported seeing the ticker across the screen, however all of them instigated protective action based on different information sources (Figure 4.5). Those watching the game emphatically voiced how the tornado information provided was inconsistent, leading them to question the credibility of other sources:

> The reason [NBC] didn't bleep in is because it was the Cowboy's game in Dallas, and they knew that they would be criticized no matter what. They chose to stick with the game, however at half-time, they did put a little blurb

> up there in the corner [scrolling ticker], but that was it, and I didn't pay any attention. (Participant 13)
>
> We were sitting there watching the football game and the alarm went off on my husband's phone… and of course nothing yet had broken out yet on the TV, where the Cowboy's game was showing it. He kind of looked at me and said, "it can't be that bad, they haven't broken into the TV broadcast yet." (Participant 20)
>
> We thought watching the Cowboy's game, why on earth didn't they pause and do the alert. We were surprised by that because I had already talked to my sister on the phone. There was nothing coming across the Cowboy's game, and the alert on our phones didn't come off until about four minutes after I had already talked to my sister. We were kind of confused by everything because there was no warning during the game. (Participant 21)

Figure 4.5

Info Source that Instigated Protective Action for Participants Watching Game



For other participants, the information afforded by other sources led them to seek out information on a different television network, adding duration and complexity to their decision-making:

> We were watching the Cowboy's game and there were no warnings on or during the game. The storm was coming and we had no idea until that alarm came on my phone. I went and changed to another channel. There was only one channel that had the correct information, on channel 8, and [the meteorologist] was saying exactly where it was. (Participant 2)

> [My] phone went off, I turned on the TV, got the Cowboy's game, which made no mention at all of the storm. So I was flipping around channels to get somewhere and I came across one of the local news stations and the newscaster said, "if you live in the Preston Hollow take shelter immediately." Right as he said that, I could hear things starting to hit the house. (Participant 11)

There was a clear-cut difference between those watching the game and those watching other networks or programs. As conveyed by Participant 20, the passive warning information during the game delegitimized other social and environmental cues regarding the active tornado threat. Moreover, the delay in switching to comprehensive coverage resulted in these participants having to perform additional steps to their decision-making processes, ultimately delaying their protective action implementation. To summarize the common perspective among those watching the game:

> I can't tell you how many people I've heard that said, "while I was watching the Cowboy's game…" and that's their first sentence out of their mouth, and then "I had no idea there was a tornado coming." I feel like they're lucky that nobody died in this tornado. (Participant 2)

Mobile Devices and Information Before and During Protective Action

Mobile devices facilitated participant's capacity to gather information during their decision-making process and after implementing protective action. In other words, mobile devices functioned as an information source that allowed them to collect information from multiple channels (mobile alerts, mobile apps, peer networks, etc.) when deciding if taking shelter was necessary, as well as a source that increased their situation awareness while they were implementing protective action. Speaking on the capacity to access a variety of different information channels from a single source while decision-making:

> I was trying to identify where the circulation was. I probably have five different apps, so I would just go back and forth. I don't think that the TV even helped at that moment. (Participant 22)

> NBC 5, I have their app on my phone. So that's who I get my weather from typically and looked at after my son called us. (Participant 14F)

> I think the fact that I was in contact with a couple people texting back and forth who are not in our location, it was helpful, you know, to get some information from them as to what was going on. (Participant 6)

Other participants revealed how this information source facilitated their capacity to monitor the weather that they otherwise would not be able to while sheltering.

> I got the iPad up and running to stream the broadcast, and we were maybe in that closet what felt like 60 seconds before it hit (Participant 20).

> As soon as we got into the tub, we both had our phones and I was texting our daughter not to come home. Then as soon as the power went out, I called somebody who I had kind of been texting with on Facebook and said, "we're in the tub, power just went out, where is the tornado?" She said, "right on top of you." You know, just from her looking at it herself on the news. (Participant 4)

> We crept out. I felt like I heard wind twice. Like it hit once and there was definitely a lull, and then it started up again. So we waited again, and then it stopped, and I felt pretty comfortable then, and my mother texted again that it had passed us, so I started to poke around. (Participant 2)

Moreover, not only did respondents seek out this information, but they also shared with other individuals potentially at risk from the tornado.

> …at that time [in shelter location] then people that know where I live from work started texting me, and then I'm texting other people, "Hey lookout! I was just hit, you live close by…" (Participant 9)

Throughout the interviews participants repeatedly discussed how access to multiple information channels through a single source not only facilitated, but expedited their protective action decision-making. Once they took shelter, their ability to continue gathering information facilitated both their own situational awareness and capacity to become warning message disseminators to others they knew to be at risk.

Tornado Experience and Knowledge

The tornado experience among participants provided knowledge about

tornado safety and protective action, which facilitated their decision-making and implementation processes. Direct (e.g., surviving a tornado or a near-miss event; *n* = 4) and indirect (e.g., drills, warning events, media coverage, etc.; *n* = 19) experiences enriched their understanding of the risk posed by tornadoes, as well as how and where to most effectively take shelter in their residence. “I guess having previously being in a tornado… I knew what to expect in the aftermath, and so I knew to get away from windows to protect myself, my body my head, and to try to put as many things between myself and outside walls” (Participant 11).

While Participant 11’s direct experience supplied the knowledge of how to maximize their safety during a tornado, the indirect experiences described by participants were equally as valuable to their insight regarding how and where to protective themselves during a tornado. One participant discussed their experience regarding the nearby Garland/Rowlett tornado in 2015. “There was one other tornado that hit, the Christmas time one four years ago. I remembered taking them [childen] into the bathroom when that one was nearby, although that hit further north. So they listened and did what they were told” (Participant 3). This type of experience was also noted by Participant 22:

> I think it was May in 1996 in Leander. What was that little town near Georgetown? There was a tornado that wiped that little town off the map and that came near our house afterwards, so I saw it from a distance. It hit some of my friend’s houses that were two miles away and I could see the tornado. (Participant 22)

As described by Participant 23, “we’d always go to the cellar, our neighbor had a bomb shelter and we’d always go down [there].” Because of the minimal warning lead time for this tornado, having a plan that easy and quick to enact was a measure of preparedness that greatly facilitated their protective action implementation. In general, these plans did not extend beyond taking shelter in an

interior hallway, closet, or bathroom.

> I mean just kind of typical protocol, you hear the sirens and you go someplace safe and usually just wait it out. I grabbed my husband, I don't remember if he heard the sirens, but yeah, I grabbed him and my daughter and we just kind of went to the bathroom like we always do whenever they go off. (Participant 6)

Indirect experiences comprised of more than specific tornado events discussed by participants. Having lived in an area with a culture of tornado preparedness (such as Texas) resulted in participants implementing protective action instinctively and quickly. Speaking to the culture of tornado preparedness, Participant 16 noted, "I am a long-time Texan and when they [issue] a tornado warning I go and take shelter, period. I don't try and ride it out." A fundamental element in communities with a culture of tornado preparedness are shelter-in-place drills:

> I knew to go inside hallways. I've always heard that, and I'm a teacher, retired teacher, we used to teach the children that. (Participant 13)

> Growing up they always make you do the tornado drills. That was something that was done pretty regularly in our school. I mean you pretty much learn what the signs are from your classes. I would say growing up it's pretty much, we were taught what to look for and where to go and seek shelter and things like that. (Participant 6)

Members of a community with a culture of tornado preparedness, regardless of their specific type of experience, benefit from this way of life through learned knowledge and understanding of what to do during a tornado. In a tornado with minimal lead time, such as the 2019 Dallas Tornado, this knowledge-driven instinct was a substantial facilitator, especially when coupled with a clear and concise tornado warning message.

RQ3: Anticipated Effects on Future Decision-Making and Action

To examine how risk perceptions and decision-making processes were affected by this tornado participants were asked about any changes they expect to

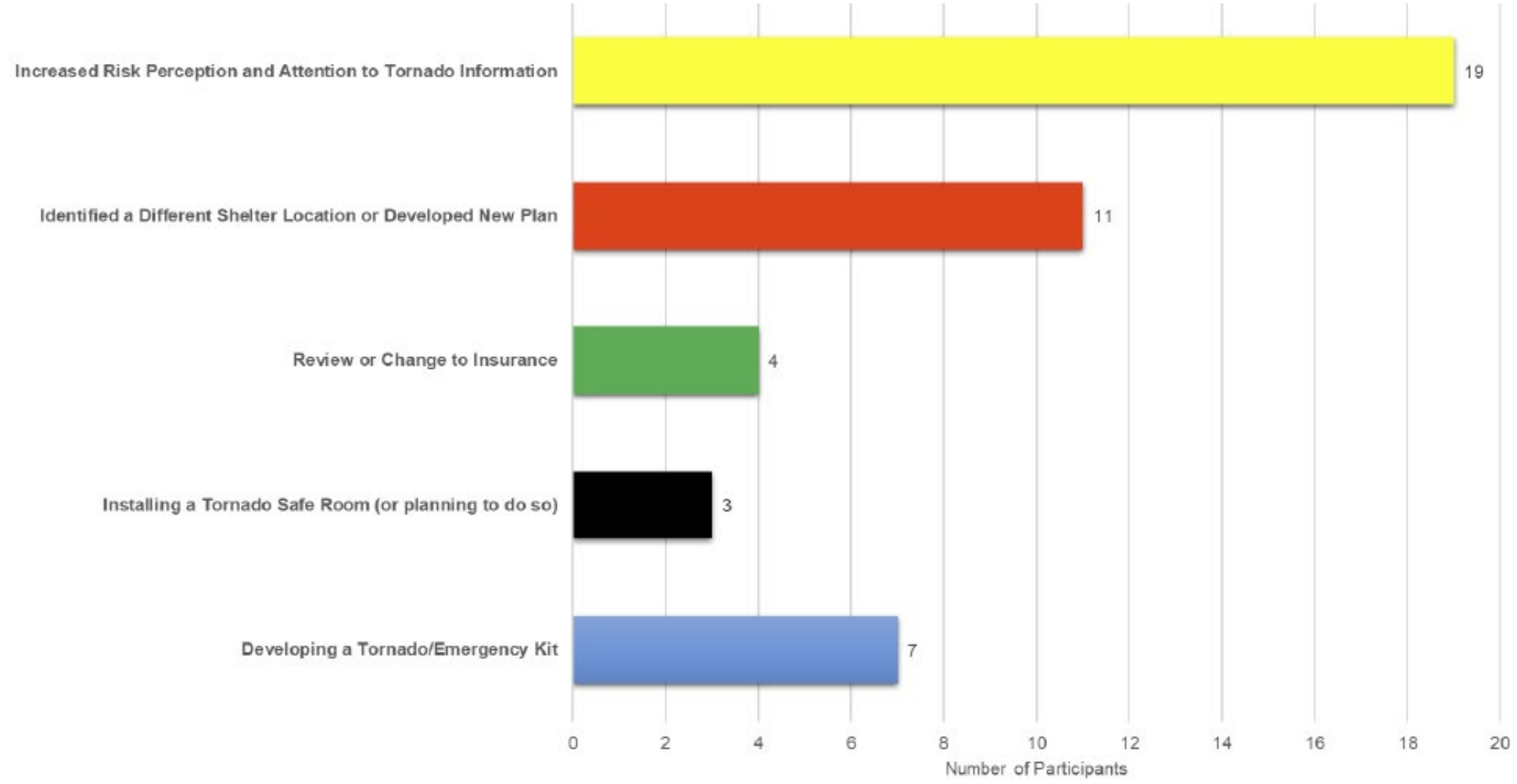
make during future tornadoes. This enquiry investigated their anticipated behaviors, changes to their household plans, and their adoption of tornado adjustment or mitigation measures. Not surprisingly, 19 of the 23 participants discussed alterations to how they expect to respond to future tornado events and 11 spoke about specific adjustment measures they have already adopted or are in the process of doing so. The themes that emerged pertaining to RQ3 include participant's changes in risk perception to future tornadoes and the implementation of adoption of tornado adjustment measures.

Changes in Risk Perception to Future Tornadoes

Taking protective action in response to warning messages requires not only a sufficient risk perception for tornadoes, but also the capacity to receive these alerts (both the alert tone and information). Although not all of the participants viewed being hit by another tornado as necessarily more probable, their intimate knowledge of the consequences because of this tornado led to three expected modifications to their preparedness and response behaviors. First, and the most common change (*n* = 10), is their expected attention to future warning messages. This finding also reflects the discrepancy previously discussed regarding participant's ability to receive a mobile alert (*n* = 23) and their attention to the threat they faced during the Dallas Tornado; with only six participants taking immediate action following their initial notification from mobile technologies, television, or other social cues. All of the participants who took protective action, as well as those who took no action, expressed that they will take future severe weather and tornado warnings seriously. Participant 14M commented on this by noting, "I mean I think I'll pay closer attention to weather alerts. I know ever since the tornado, I don't think that I'll ever be the same as far as when severe weather is around."

Figure 4.6

Participant Adjustment Measures



Another behavioral change expressed by participants was ensuring that their mobile devices both had the volume for emergency notification turned on overnight and were adequately charged.

> I feel like now just in general after this experience I take every warning, or hearing about bad storms, or more alert to the news and looking up myself on my phone weather reports and stuff. I just go to Weather.com if I hear storms are coming or I turn on the news, but if I know there's going to be storms I do turn to the news channels more to see what they're saying about the storms, which I never did before. (Participant 5)

Looking back, participants who did not take shelter, or those who delayed taking action felt their risk perception for tornadoes was flawed. Although they shared how this was disadvantage to their protective action decision-making process during this tornado, they assert that they will heed all future tornado warning messages and engage in sheltering behaviors quicker.

Tornado Adjustment: Insurance and Mitigation Measures

For participants to engage in tornado adjustment measures (e.g., insurance changes, structural hardening, etc.) they must perceive these measures as both effective and necessary. Participants' experiences with structural insurance were split between those owning a condominium (n = 14) and those owning a house (n = 9). Only one participant in the study reported renting their home at the time of the tornado and denied making any future adjustments to their tornado coverage, as they are relocating to a region facing less of a tornado threat. For condominium owners, structural insurance was provided through their homeowner's association, and the rebuild of the residence was fully covered. The only hazard mitigation adjustment measure discussed by these participants was that their new residential structure is upgrading from single to double pane windows.

The participants owning their own homes noted that while their insurance

policy is covering the rebuild of their structure to its pre-tornado specifications, financing for additional tornado adjustment measures was an out-of-pocket expense. The installation of a tornado safe room as an adjustment measure was only seriously discussed by three participants in this study. There were two reasons for this that stood out. First was the cost, either because it was not covered through their insurance or it would increase the overall cost of the rebuild through the development of new architectural plans. The second reason was more specific to this tornado, in that they were adequately protected by their home and their personal safety was less of a concern. As Participant 2 articulated, “We’re just building another regular house and praying it never happens again… I mean we will have interior spaces for safe places.”

Only a few (*n* = 3) participants indicated the inclusion of a tornado safe room in the reconstruction of their house. In contrast, for Participant 21 expressed their desire to install a tornado safe room, however their insurance coverage is delaying the process, “We just renewed our homeowner’s insurance, but until the house is complete we are not going to change the amount, until we finish construction.” Participant 4 found themselves in a similar situation regarding the lack of insurance support for installing a tornado safe room, however their experience led to a different response, “We’re going to get different insurance [provider] and we want to put in a shelter as well, but not like a separate room but like as a closet that could be a shelter.” Unfortunately, the cost of a safe room and the lack of insurance assistance frequently superseded participant’s desire to structurally mitigate their home for future tornadoes.

> We went back to the same architectural plans and tweaked them. We have that closet [and] I have debated making that a true safe room but [am leaning against doing this now]. It’s really more of two reasons: A, the cost; and B, truly what are the odds of a tornado hitting that same house twice. It’s like are

> we spending the money on a safe room for a true need for safety or are we spending the money on a safe room out of fear and to make us feel better? Certainly fear and feeling better sound good, but those steel boxes are not cheap. (Participant 20)

Having a debate over whether or not to install a tornado safe room was not universal. In discussing the reconstruction of their home, Participant 3 noted, “We put a storm room in. I feel like I read an article that said 40 years before there’d been a tornado that had kind of gone through the exact same path, and I was like [we] may not be here [then], but let’s put this room in anyways.” For the participants who were displaced (*n* = 22), many of which expect to be displaced for more than a year after the event (*n* = 12), both the desire and capacity to adopt hazard adjustment measures was significantly affected. This was especially true for those living in temporary housing because of their inability to modify their current residential structure.

Tornado Adjustment: Preparedness Measures

The final tornado adjustments and preparedness measures adopted by participants reflected the non-structural changes they could make, which were more cost-effect and practical if they did not have the capacity to make alterations to their new home during the rebuild process. These measures included the development of tornado response plans, increasing the number of ways to be notified about a tornado, and purchasing supplies to be better prepared should they go through a similar event in the future. For Participant 16, a condominium resident living on the second story, her plan before this tornado was to take shelter with her downstairs neighbor. Although she had the time to execute this plan during this tornado when she got downstairs, she discovered that her neighbor was not home, and the door was locked. Participant 16 articulated that if she knows that severe weather is

forecast, “I will call my neighbor earlier in the evening and ask are you going out to dinner? Maybe you could leave your door open.”

In regard to enhancing the probability of receiving a tornado warning alert and increasing the amount of lead time to take protective action, Participant 23 exemplified this common sentiment by conveying, “I signed up for apps where they send you weather alerts… We have Fox 4 Dallas News, Fox News, NBC 5, The Weather Channel, Traffic.com, and WFAA 8… I want to be bombarded with tornado alerts.” Additionally, Participant 14M, who relied on amateur radio over social media during this tornado, communicated, “I just got a new scanner and was trying to get the weather stuff up on the scanner, but it was easier to hit the iPhone and watch the weather radar that way.” Speaking more to the timeliness of tornado warning messages, this participant adds:

> Given two minutes and some information and knowledge of where the tornado is, I will seek the closest area underground, which happens to be a parking lot at the Chase building about one or two minutes from here, but I will no longer sit and wait without having a storm shelter. (Participant 14M)

There were several different measures that participants made to help prepare themselves in the event of another tornado impacting their home. One measure that participants discussed was creating a “tornado kit” for their identified shelter location. Taking items from around the house such as bicycle helmets, flashlights, emergency provisions, and other objects was a popular activity communicated. Participant 8 noted, “Now I have a bicycle helmet in the closet right next to my bathroom. I’ve got flashlights close by there as well.” Additionally, Participant 7 expressed they “put a bottle of distilled water in there, I probably need to add a first aid kit and probably maybe some granola bars or something like that, to just keep in the close.” Additionally, the purchase of new items was discussed.

> One thing we did do is that we bought a generator now. I bought these light bulbs, and they charge while they're being used, but if you have an emergency or if the lights go out that bulb comes on, but even if it doesn't, you can take it out of the lamp and push a button and turn it into a light. (Participant 12)

Interestingly, Participant 12 was the only interviewee who discussed how putting together a tornado kit with other emergencies in mind, such as a power outage. Nevertheless, the adoption of cost-effective, non-structural tornado adjustment measures was something participants viewed as simple activities that would help them in the future.

CHAPTER 5

DISCUSSION

While this study reaffirms elements of the PADM that represent protective action decision-making as a linear process, it makes several new contributions. First, this was a nocturnal tornado in an urban area. The temporal context meant this was a short-fuse warning situation where the warning message was the sole vehicle for instigating protective action. The event's setting meant there were a wide variety of housing tenure situations that shaped decision making processes, and one in particular (condominuim ownership) has not been thoroughly explored by previous research. Next, the contemporary technological culture has a profound influence on how people appraise and make protective action decisions when facing an imminent tornado threat. The versatility of smartphones and other mobile technologies allow people to access any number of desired information sources through a single information channel. In particular, people can gather this information before, during, and after the implementation of protective action. Finally, these findings suggest a reimagining of the PADM in accordance with this hazard scenario and the contemporary technological culture. It suggests how rapid, knee-jerk reactions may be better incorporated into the model, and how people's threat evaluation processes after successfully taking protective action suggest a less-linear feedback loop in events such as the Dallas Tornado.

Hazard Scenario

The 2019 Dallas Tornado afforded a unique scenario for research in terms of the hazard itself and the community it struck. This nocturnal tornado occurred outside of the traditional "storm season" and its short-fuse warning left those at risk with minimal time to make decisions. Moreover, the participants living in

condominiums encountered distinct challenges with adopting future tornado adjustment measures compared to their house-owing counterparts.

The autumn seasonality was a surprise among participants but had little effect on their threat appraisal. Interestingly, however, the nocturnal timing was not surprising, yet it hindered their ability to evaluate the threat. Specifically, participants discussed how the time precluded their expected evaluation behavior of looking outside to confirm the threat through known environmental cues. This coincides with prior research suggesting that nocturnal tornadoes enhance human vulnerability (Ashley et al., 2008; Brotzge & Erickson, 2010; Mason et al., 2018).

The short-fuse warning for this tornado (with most participants having less than five minutes) drove participants to make rapid decisions based on their affect heuristic, which in this scenario resulted in a “flight” response. This finding is important as it reflects the critique that “the PADM tends to neglect the role of emotion in emergency decision-making… [and] should be able to account for panic responses; but it cannot” (Tierney, 2019, p. 96). Here, participants’ affect heuristic-driven flight response in their protective action decision-making was a “fast, instinctive, and intuitive reaction” after learning about the tornado threat (Slovic et al., 2004, p. 311). It is worth noting, however, that while participants often described their response as “panic”-driven, the descriptions of their response behaviors instead reflected an immediate flight instinct based on their preexisting tornado knowledge and experience.

Warning research shows that an effective message communicates information about a threat such as the type and severity, location, timing, PAR, and source (Kuligowski & Kimball, 2018; Mileti & Peek, 2000; Mileti & Sorensen, 1990; Sutton et al., 2014) and does so with consistency across the different channels

available to those at risk (Drabek, 1986; Lindell, 2018; Mileti et al., 1975). Participants who were watching the Dallas Cowboy's game when the tornado struck epitomize how a failure to incorporate these features of an effective warning message may impede protective action decision-making and implementation. Compared to other tornado warning sources (e.g., mobile alerts, outdoor sirens, etc.) television broadcasts can provide a visual and geographic representation, which some studies suggest "far outweighs other factors when predicting warning response" (Schumann et al., 2018, p. 327) (see also Balluz et al., 2000; Drost et al., 2016; Wolf, 2009). This resource, unfortunately, was not provided to many participants during the 2019 Dallas Tornado.

Finally, research on housing reconstruction has mostly focused on single-family housing, with the reconstruction timeframe being influenced by household demographic characteristics such as number of residents, income, race/ethnicity, and gender (Bolin, 1993; Bolin & Bolton, 1986; Bolin & Stanford, 1998; Peacock et al., 1997). Drawing from the research by Rumbach et al. (2020), which identifies mobile home residents as a "third type" of housing tenure arrangement, condominium owners emerged as a similar unique population in this study. Condominium owners, much like mobile home residents, are a population that owns their home but does not have sole control over the property where they reside. Unlike those who own a house and the property underneath, the condominium owners in this study face three distinct hurdles: (1) nearing the one-year anniversary of the tornado they all still remain in temporary housing, with the rebuild permits for their complex yet to be processed; (2) they are still responsible for their HOA dues (appx. $700) despite not being allowed to return to their home; and (3) they have minimal input regarding the complex's reconstruction and hazard mitigation. To this

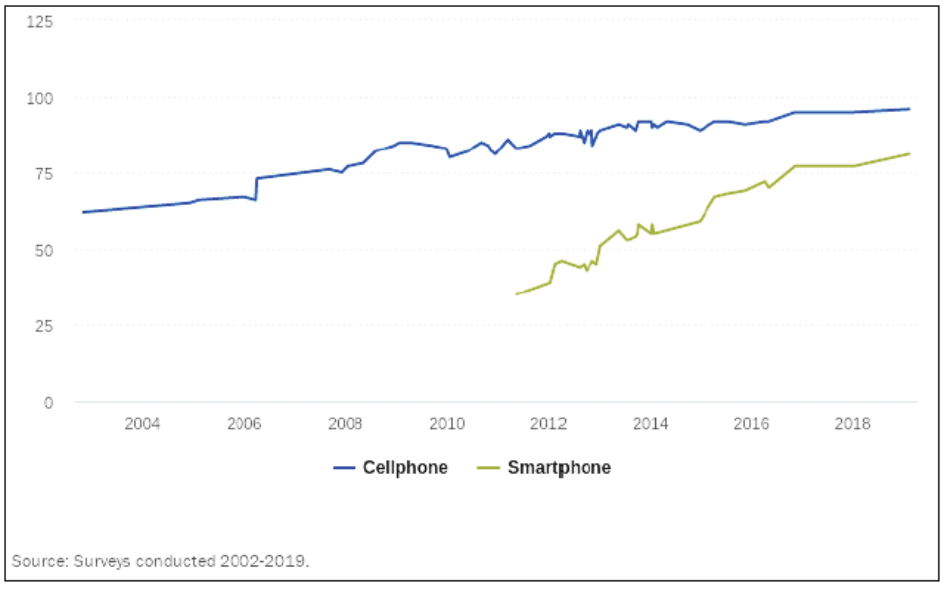
third hurdle, insurance coverage is governed by the condominium's HOA, and condo owners do not have the option to elect to install tornado safe rooms or other structural mitigation measures. Therefore, not only are they at a disadvantage during recovery, but they have minimal input regarding their resilience to future tornadoes.

Contemporary Technological Culture

While this study reaffirms existing research on warning messages, such as the importance in warning message consistency and variety of channels (Drabek, 1986; Lindell, 2018; Mileti et al., 1975), this study makes new contributions regarding the contemporary technological culture and protective action decision-making during tornadoes. Arguably the most important finding of this study was the versatility of mobile technologies in affording a vast number of information sources from a single channel. Considering 96% of U.S. adults own a cellphone and 81% owning a smartphone (Pew Research Center, 2019), understanding the role of these mobile devices during tornadoes is paramount (see Figure 5.1).

Figure 5.1

Mobile Phone Ownership in the United States



Source: Pew Research Center(2020)

Researchers studying severe weather warnings specifically have noted a lack of focus on the impact of contemporary technology on decision-making during tornadoes (Sanders et al., 2020; Stokes & Senkbeil, 2017).

For the participants in this study, mobile devices were both a resource providing an initial warning (mobile alerts and social networks) and a link to information source(s) they desired most (social media, mobile applications, social networks, etc.). More importantly, mobile devices allow people to choose whichever information source they deem most credible. This suggests the “stakeholder perceptions” element of the PADM is less relevant to decision-making, especially with secondary information sources, compared to past tornadoes because people’s situational awareness is determined more so by what is sought out rather than what is simply provided to them. Additionally, this information is accessible after protective action has already been implemented, allowing for people’s information search strategy to transpire as a separate process outside of their initial decision-making. For example, as many participants in this study illustrated, protective action was taken first and then followed by an information search to confirm their threat exposure, which the PADM identifies as a “pre-decision process” (Lindell, 2018).

Social media can serve as a double-edged sword with decision-making. On one hand, it provides access to useful information from stakeholders and social connections; while on the other hand, this information lends itself to distortion and/or complexity (Sullivan & Koh, 2019). In this study, the use of social media was a participatory information seeking process through both trusted stakeholders and social networks, which disaster research demonstrates can provide specific event-related situational awareness (Palen & Hughes, 2018). Social media was a resource for evaluating the threat after the protective action decision-making and

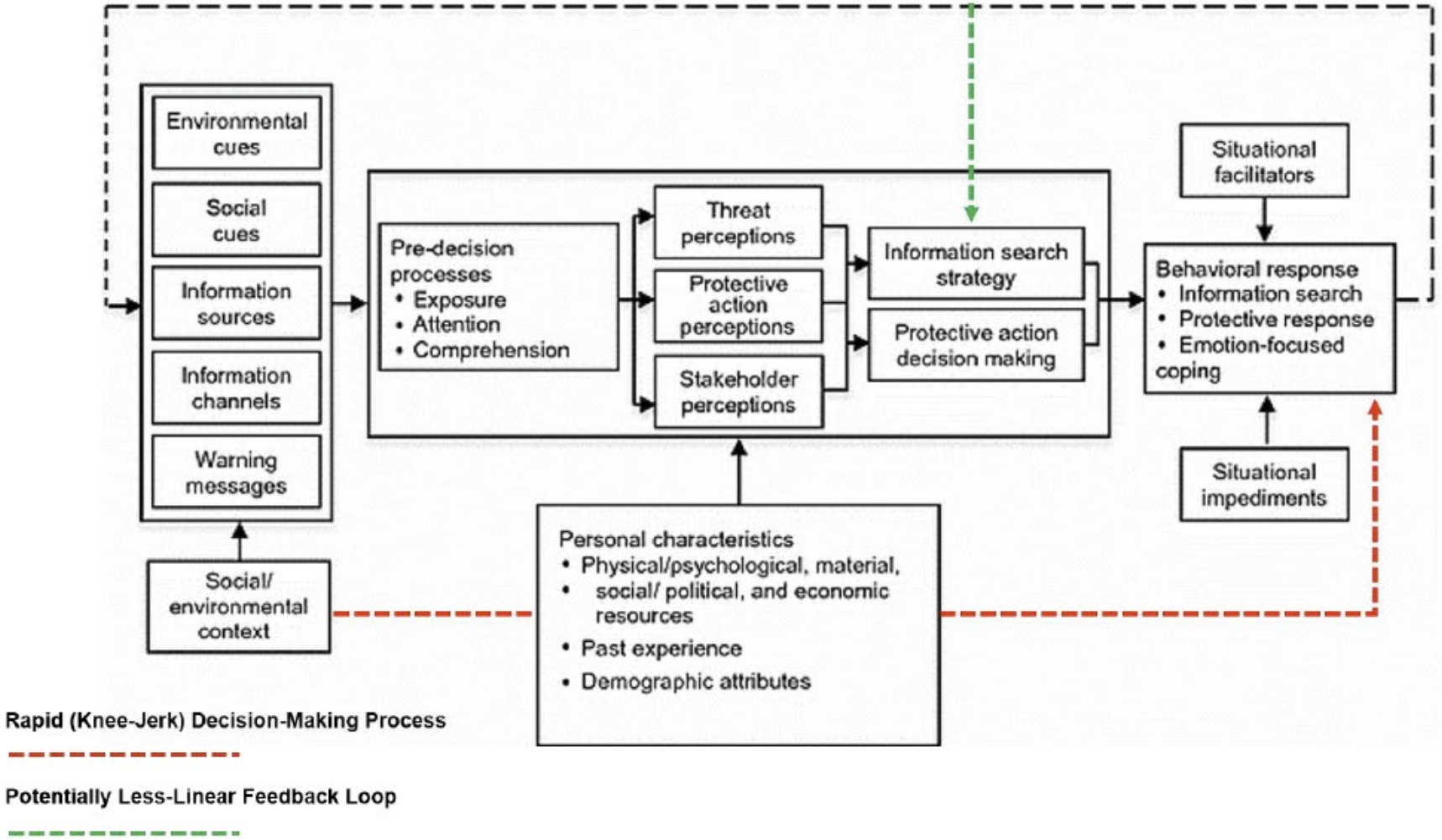
implementation was already achieved. This suggests the PADM as a whole is more complex and potentially less linear.

Reimagining of the PADM Based on the 2019 Dallas Tornado

The findings of this study regarding the hazard scenario and contemporary technological culture suggest a reimagining of the PADM to better interpret decision-making during rapid onset hazards such as the 2019 Dallas Tornado. Participants in this study expressed how their initial warnings led to a knee-jerk protective action response and information seeking once this action was achieved. This suggests a connecting line in the PADM from the social/environmental context to the personal characteristics element and continuing on to the behavioral response element. This also suggests that the feedback loop from the behavioral response element to the beginning of the model have an additional line deviating to the information search strategy element. While the behavioral response element does include an information search component, in this scenario participants were in fact formulating their strategy for gathering information after already sheltering. Therefore, because of the resources afforded by contemporary technology, the decision-making process was less linear compared to the current iteration of the PADM during the 2019 Dallas Tornado (see Figure 5.2).

Figure 5.2

Reimagining the PADM with the 2019 Dallas Tornado



CHAPTER 6

CONCLUSION

This study on protective action decision-making examined the 2019 Dallas Tornado using the most recent iteration of the PADM. Semi-structured interviews and a qualitative analysis approach allowed this study to understand participants' threat belief and evaluation processes (RQ1), situational impediments and facilitators in this event (RQ2), and the anticipated effects on future decision-making and protective action in tornadoes (RQ3). For RQ1, the findings revealed how a lack of pre-tornado observations and forecasts were disadvantageous for participant's belief and evaluation processes, while mobile alerts and social networks satisfied these processes. The impediments to decision-making and protective action (RQ2) were a short-fuse lead time and a delay in televised warnings, while information through social networks and tornado experience (availability heuristic) facilitated decision-making and protective action. Finally, participants expressed a higher risk perception for future tornadoes and capacity to put into action simple and cost-effective preparedness measures (RQ3).

The key takeaways from this study are how affect heuristic-driven rapid (knee-jerk) reactions led to successful protective action despite a short-fuse warning and that mobile technologies allowed access to multiple information sources from a single channel. When participants learned of the threat, often passively via mobile technologies, they attributed their rapid reactions to their tornado knowledge and experience. After taking protective action, mobile devices continued to facilitate their situational awareness by allowing them to actively seek information to confirm the tornado threat. Therefore, this study suggests a reimagining of the PADM to better incorporate rapid (knee-jerk) reactions and the capacity to seek out information

throughout the protective action decision-making process because of the contemporary technological culture.

Major Contributions

This study contributes to existing knowledge in disaster science in several ways. First, research on protective action decision-making has largely been quantitative. Qualitative case studies such as this are important to understanding why and how people evaluate the threat of tornadoes and make protective action decisions. The PADM represents a linear process of evaluation and decision-making, however, during a tornado with a short-fuse warning, asking people “why” and “how” revealed a less-linear process. Specifically, knee-jerk reactions driven by the intrinsic knowledge of a hazard expedited decision-making and much of the evaluation process took place once protective action was achieved. Equally important was the capacity to continuously reevaluate the threat while sheltering, thanks to the ability to seek out information from smartphones and other mobile devices.

Second, this study revealed the extent to which smartphones and other mobile devices provide access to information from many different information sources through a single information channel; not only do these devices disseminate information to those at risk, but they also enable people at risk to actively seek information from familiar and trusted sources. Thus, information may be actively gathered rather than only passively received. Further, traditional tornado information sources such as television or outdoor sirens necessitate that people stay within visual or hearing range. Comparatively, smart devices allow people to gather information throughout their decision-making process and after protective action is taken.

Third, this study showed condominium owners to be a population with unique recovery barriers and limited ability to enact desired tornado mitigation strategies. Even though condominium owners do hold title to their home, they only control the interior. The property and physical structure are separately controlled and (in this study) managed by an HOA. This type of ownership structure creates complexity during disaster recovery with the property's owner and/or HOA being responsible for the rebuild rather than the condominium owner, which research on this population suggests can take much longer compared to those owning a house (see Wu ,2004; Wu et al., 2007). Moreover, this complexity persists into the mitigation and preparedness for future disasters with legal ramifications for insurance, long-term maintenance, "betterment" (i.e., resilience), and recovery planning for future disaster responsibilities (Finn & Toomey, 2017). Therefore, while Rumbach et al. (2020) identified mobile home residents as a "third" housing demographic based on their divided-tenure arrangement, the findings of this study suggest the condominium owners may represent a "fourth" housing demographic facing similar issues.

Practical Implications

The findings of this study suggest several practical implications that may benefit stakeholders, and society in general, during future tornadoes. First, assigning a unique tone to mobile alerts for tornado warnings to improve awareness of that specific threat. A primary reason that participants reported ignoring the mobile alert (initially or altogether) was they presumed it to be an Amber Alert because of the universal tone accompanying mobile alerts. This was especially problematic during this event because of a lack of pre-tornado environmental cues and short-fuse warning time. A unique, yet familiar tone for tornado warning alerts could avoid confusion and increase appropriate protective action responses. For example,

participants in this study recognized the sound of outdoor sirens as indicatory with the threat of a tornado. As such, this sound accompanying mobile tornado warnings may be more effective with quickly satisfying people's threat belief. Additionally, when communities test their outdoor sirens, there are potential benefits with also testing the local mobile alert system, if doable. The trust participants have with outdoor sirens suggests that not only do regular (monthly) tests reinforce community awareness to the threat posed by tornadoes, but they also can increase a community's trust in local stakeholders as taking a proactive approach to ensure their safety during tornado events.

Second, developing more formal partnerships between emergency management stakeholders and private entities would facilitate clear and consistent messaging during potentially life-threatening events. This information disparity was highlighted by participants watching the Cowboy's game on NBC compared to those watching other television networks or seeking out information through other mediated communication sources (e.g., social networks, social media, mobile apps, etc.). The problem identified in this scenario was two-fold: (1) for those watching the game, the scrolling ticker and brief interruptions during commercials failed to provoke an urgency to the threat; and, (2) for those who turned on NBC to seek out information the lack of geographic context and clear assertion that the tornado was imminent, was inconsistent with other mediated communication sources. Specifically, participants emphasized how critical the difference is between information presented as a scrolling ticker and the same information being communicated by meteorologist with visuals imparting geographic specificity (i.e., dedicated coverage).

Third, the findings for RQ3 suggest that public awareness campaigns for household tornado preparedness will benefit most by promoting simple and cost-

effective adjustment measures. While some participants discussed more comprehensive adjustment measures (e.g., changing insurance policies, installing tornado safe rooms, etc.), most expressed that developing a tornado or emergency kit for their shelter location and predetermining their tornado warning and information sources are more feasible adjustment measures. This was especially the case for those with little input regarding the rebuild of their home such as condominium owners and those with homeowner's insurance policies that do not include additional structural mitigation measures during reconstruction.

Finally, condominium property owners and residents (as well as the HOAs) should develop pre-disaster recovery plans for tornadoes and other potential hazards. Specifically, these plans can benefit residents by establishing the reconstruction and financial responsibilities for both themselves and the property's owners, as well as familiarizing both parties with the short- and long-term recovery processes.

Limitations

The design of this study is not without limitations. One shortcoming of this research was the homogeneity among participants, with every participant having at least some college education and only five interviews with males conducted. Further, demographics such as race/ethnicity and socioeconomic conditions were not included in this study, however based on the interviews it is reasonable to assume that most or all of the participants were white and, on average, more affluent. This homogeneity regarding race/ethnicity and socioeconomic status is also representative of the Preston Hollow neighborhood in North Dallas (see Figure 3.2).

Another limitation in this study was urban setting for this tornado, or rather there may be a lack transferability in the findings of this study in more rural or less

densely populated areas. This same limitation may also reflect areas with greater diversity in race/ethnicity, socioeconomic status, or other demographic characteristics. Additionally, qualitative methods provide the opportunity to collect rich and meaningful data that allows for a deeper understanding of the various dimensions of decision-making; however, these methods are limited in their capacity to provide a comprehensive analysis decision-making during this tornado. However, some of the of these experiences may be transferable to other contexts where urban and/or nocturnal tornadoes are the focus of study.

A final limitation of this study was the recruitment of participants over social media. Although this was an effective method for reaching out to eligible participants, it also reflects participants that possess at least some level of technological comprehension and actively engage with social media. It is important to acknowledge this as a potential limitation with the finding of this study indicating the contemporary technological culture and social media as contributing factors to threat appraisal and decision-making.

Future Research

The findings and limitations of this study evoke the need for further inquiry. Considering the emerging role of mobile technologies with warning reception and protective action decision-making, future research should investigate how people rely on mobile technologies not only as a primary warning source, but also as a secondary information source before and during protective action implementation.

This study found the nocturnal timing to be unsurprising, yet a factor effecting people's threat evaluation capacity. Comparatively, the occurrence of this tornado in the autumn caught participant's by surprise, but it had little effect on their threat belief and evaluation. Therefore, another avenue for research is how seasonality and

timing might affect threat belief and evaluation during tornadoes, and other hazards with a perceived temporal consistency (e.g., extreme temperature events, hurricanes, flash flooding, etc.).

Next, this study found that knee-jerk reactions were a factor with protective action decision-making and implementation that circumvents the traditional flow and process described in the PADM. Future research testing the PADM (or other similar models) should account for this reactive response not only in tornado events with a short-fuse warning, but also with sudden onset hazards including earthquakes, tsunamis, and wildfire events, among others. Moreover, including this factor in quantitative studies may offer more comprehensive insight about the occurrence of reactive responses among a larger sample population and across different demographic characteristics.

Finally, future research is needed to reveal the complexities during recovery for condominium owners. For instance: (1) What challenges arise as a result of lacking sole ownership and control of both their home and property? (2) What are some of the similarities and differences in recovery that can be drawn between condominium owners and divided-tenure populations such as mobile home residents? (3) Do condominium owners and divided-tenure populations, take longer to return to their pre-disaster state and permanent housing? (4) Compared to other housing-tenure types, to what capacity are condominium owners able to implement structural and non-structural mitigation activities? These questions provide examples on how future studies can examine resilience and vulnerability among condominium owners and other divided-tenure housing groups.

APPENDIX A

INTERVIEW GUIDE

1. How did you first learn about a possible tornado?
    - When and where was this?
    - What were you doing?
    - Tell me what was going on around you. Was there anything (else) or anyone (else) that clued you into a possible tornado threat?
2. Tell me what you thought and felt when you first learned about the tornado threat.
3. Now tell me about what you did when you learned of the tornado threat.
    - How much did you trust or believe in the first information you saw or heard?
    - Did you obtain this information from a source that you were familiar with and/ or trusted?
    - Did you understand everything in the information you saw or heard?
    - Did you seek out any additional information?
    - Was this how you expected to find out about a possible tornado? If not, how do you normally expect to find out about a tornado?
    - (If action was taken) How much time passed between when you first learned of the threat and when you took action?
    - (If environmental cues are mentioned) What are you looking for outside when you after learning about a possible tornado?
4. Do you view your chosen course of action as successful? Why or why not?
    - What skills, resources, or knowledge do you think contributed most to the success of your actions?
    - Was there anything or anyone else motivating this course of action?
    - Did you have a tornado plan before this tornado? If so, tell me about it.
    - How long did you take protective action for? What made you stop taking protective action?
5. Had the circumstances been different, is there another action you would have rather taken? If so, what?
    - Did anything prevent you from taking the action you most desired?
6. What actions will you take the next time you receive a tornado warning?
    - What will be different about next time compared to your previous experience? (Different plan, trusted information source/channel, etc.)

- Based on this previous experience, do you anticipate making any changes to your home or to your behaviors between now and then?

7. What advice would you give someone else faced with the possibility of a tornado impacting them?

8. Demographics

    - Did your place of residence or property incur any damage from the tornado?

        i. If yes, what sort of damage did your home incur?

    - Was this the first tornado you experienced? If not, briefly tell me about your previous experience with tornadoes.

    - At the time of the tornado did you rent or own your home?

    - Who all lived in your household at the time of the tornado?

    - What is your age? (and others who were at your home during this tornado)

    - Do you have any pets in the home?

        i. If yes, did they affect this experience or your decision-making process in any way?

    - What gender do you identify as? (if not obvious)

    - What is your highest level of education completed?

9. Is there anyone else you know who was impacted by this tornado and might be willing to speak with me?

APPENDIX B

SOCIAL MEDIA RECRUITMENT POSTS

First Post—June 26, 2020

> I'm a grad student doing my thesis research project on this event. If anyone is willing and comfortable sharing their experience with me, please feel free to send me a message for more information.

Second Post—September 22, 2020

> I want to thank everybody in this group who shared their tornado experience with me for my research/thesis project. I've heard many amazing stories over the phone and would love to hear more. If anyone is willing and comfortable sharing their experience with me please feel free to send me a message, and if you're someone I've already spoken with, please feel free to share my post/information with anyone else affected by this disaster. Thanks, and stay safe.

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